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THE AUTHORS OF THE SEVERAL PAPERS ARE INDIVIDUALLY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

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CONTENTS OF VOLUME XXVII.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART I., 1914.]

ART. I—*Victorian Holothuroidea, with descriptions of New Species.*

BY E. C. JOSHUA.

(With Plate I.),

[Read 12th March, 1914].

In the following paper fifteen species are dealt with, four of which are believed to be new to science. No attempt has been made to give a complete synonymy of each species, but a reference has been given to where such may be found. The author desires to express his thanks to Professor Spencer, the Director of the National Museum, Melbourne, for permission to make an examination of the specimens contained in its collection, in which all those dealt with are included; he also wishes to thank Mr. J. A. Kershaw, the Curator of the above institution, for much kindness and attention received from him. To Dr. T. S. Hall, of the Biological department of the University of Melbourne, his thanks are due for most useful guidance given on many occasions, particularly in connection with the literature of the subject. Very valuable assistance in collecting has been given him by Mr. H. Roebuck, a Geelong naturalist, and by Mr. James Wilson, in the making of arranged slides of the spicules found in some of the species. He particularly desires to thank Professor Dendy, of King's College, London, for very kindly comparing specimens of *Chiridota dunedinensis*, Parker, with that of the Author's *Trochodota allani*.

Taxonomy.

The system of classification adopted in this paper is that of Ludwig (16), but Ostergren's revision of the Paractinopoda is used in dealing with this order.

The genus *Taeniogyrus* is discarded; the writer is of opinion that the genus qua genus never had any real existence, Semper's language in dealing with it conveys little more than the suggestion for a genus, and in his catalogue and synonymy he entirely ignores it. Clark (3) has taken it seriously, and I followed him in describing *Trochodota allani*, but more recently the examination of numerous specimens of this species has definitely shown me that

the wheel papillae and aggregations are not constantly met with, and that in numerous individuals the distribution of the wheels could only be described as scattered everywhere, thus combining in one species the characters of two genera. So great an authority as Dendy will have neither of these genera, and adheres to the original genus *Chiridota* for the reception of all these wheel-bearing forms. Personally, I think that the genus *Chiridota* may be usefully separated from the sigmoid bearing genera on account of its members exhibiting bracket shaped ossicles; there would appear to be no species having an ossicle which could be described as intermediate in form between a sigma and a bracket.

Verrill's genus *Leptosynapta* is used for the species *dolabrifera* Stimpson, Clark (3) having definitely pointed out the propriety of this course.

The following is a list of the species dealt with :—

Stichopus mollis (Hutton).
Stichopus simulans Dendy.
Cucumaria inconspicua Bell.
Cucumaria mutans, sp. n.
Phyllophorus dearmatus Dendy.
Phyllophorus vestiens, sp. n.
Colochirus spinosus (Quoy and Gaimard).
Colochirus doliolum (Pallas).
Psolidium convergens R. Perrier.
Caudina chilensis (J. Muller).
Leptosynapta dolabrifera (Stimpson).
Chiridota gigas Dendy.
Chiridota ingens, sp. n.
Trochodota allani (Joshua).
Trochodota roebucki, sp. n.

GENUS STICHOPUS.

STICHOPUS MOLLIS (Hutton).

For synonymy see

1907. Stichopus mollis, Dendy and Hindle (5); and
1887 Holothuria victoriae, Bell (1);
1913. Stichopus mollis, Erwe Willy (8).

After reading Bell's account of his Holothuria Victoriae, and examining the figures he gives of its spicules, I have no hesitation in synonymising it with Hutton's species.

This Holothurian is common in Port Phillip Bay, and at numerous localities on the coast. Young specimens may frequently be met with on rocks just below low water mark, the older animals prefer deeper water.

Stichopus simulans Dendy and Hindle.

For synonymy see

1913. Erwe Willy (8).

On several occasions I have made preparations of the skins of Holothurians, which, before seeing Dendy and Hindle's paper, I regarded as specimens of *Stichopus mollis;* they, however, exhibited the peculiar dichotomoid ossicles described by Dendy (4), (5), in addition to the ordinary spiculation, and must therefore be regarded as belonging to the above-named species.

GENUS CUCUMARIA.

Cucumaria inconspicua Bell (1).

I have collected numerous specimens of this little holothurian at Flinders; the form described by Bell is usually found between tide marks, but it is also met with in water of from five to ten fathoms in depth—these latter specimens do not quite accord with Bell's account of the distribution of the podia in his type—in the strictly littoral forms the pedicels may be described as ventrally confined to the radii, and dorsally almost so; but in those collected in deeper water, the arrangement in rows is quite lost dorsally, but the ventral disposition remains the same; the result is an animal whose external appearance is identical with *Cucumaria parva*, Ludwig; the spiculation, however, is unaltered, and the details of the internal anatomy are the same as in the shore specimens. In addition to the large cruciform bodies I found numerous small rods branched at the ends, and very numerous minute (32 μ) dichotomously foliaceous ossicles, which in some individuals occur in dense crust-like patches. This animal has the curious brood-sheltering habit noticed by Ludwig (17) in *Cucumaria parva*. I have never seen the young actually adhering to the parent, but on placing some living specimens in a narcotic solution, after removing the larger animals, a number of minute individuals of from 1 to 3 mm. in length were found at the bottom of the receptacle; these can only be assumed to have become detached from the older specimens. The spiculation of the young animals agreed with that of their parents.

I think that there can be no doubt that this species is very close to, if not identical with Ludwig's *Cucumaria parva*. It is to be noted that Ludwig (17) has pointed out that so far as *parva* is concerned, the process of reproduction may occur before complete development of the spicules has been attained.

CUCUMARIA MUTANS, sp. n. (Plate I., Figs. 1 (a), (b), (c), (d).)

Localities.—Port Phillip Bay, Westernport Bay, and Victorian Coast line.

Length 60 mm., greatest width 20 mm., tapering gradually to both posterior and anterior ends. Tentacles, ten of almost equal length, pedicels confined to the radii. In the three ventral radii they occur in five closely disposed rows; in the two dorsal radii in three rows. The calcareous deposits consist of numerous tables, 80 μ in diameter, with three large central holes, and a spire having three rods, joined by a transverse beam, and terminating in six or seven spinous projections. The calcareous ring has ten pieces of about equal length, without posterior prolongations. The internal anatomy shows no peculiarities; colour, degraded white; tentacles, black.

This is perhaps one of our commonest Holothurians—the young forms being met with between tide marks in all the localities in which I have collected. It is to be noted, however, that these young forms differ very materially from the mature animal; their colour is a deep blue black, and the tables, which are crowded in the older animal, are few and far between in the young, and are usually devoid of the spire.

Though a very typical Cucumarian, its spiculation would appear to specifically distinguish it from any previously described species.

GENUS PHYLLOPHORUS.

PHYLLOPHORUS DEARMATUS Dendy.

I collected a single specimen of this animal at Flinders, and there is another from Westernport Bay, in the collection of the National Museum, Melbourne; Mr. Roebuck obtained two at Torquay. The absence of spicules in the perisome would appear to be not uncommon in members of this genus. A species about to be described exhibits the same peculiarity, and another species at present undescribed, found in South Australia, is quite devoid of calcareous bodies in the perisome, with the exception of the cribri-

form plates at the end of the podia (present also in *dearmatus* and *vestiens*). Perfectly fresh material was used for examination, so that the possibility of destruction by an acid preservative is untenable.

PHYLLOPHORUS VESTIENS, sp. nov. (Plate I., Figs. 2 (a), (b), (c), (d).)

Localities.—Port Phillip Bay, Westernport Bay, and Victorian coast line.

Size, 70 × 25 mm., fusiform flexed dorsally. Tentacles 20, ten outer, alternating with five pairs of inner, the outer dorsal tentacles are about three times the length of the ventral, the tentacles forming the inner crown do not vary in size. Tube feet are thickly disposed over the whole surface of the body, no arrangement in rows being anywhere visible. The calcareous ring (Fig. 2) consists of ten very irregular and complex processes, deeply imbedded in cartilage; the radial pieces have prolongations posteriorly. In the perisome there are no calcareous deposits other than large cribriform plates, at the extremities of the tube feet, The tentacles are provided with rods, having expanded ends pierced with several holes; they also exhibit irregularly distributed patches of small foliaceous ossicles (Fig. 2a, 2b, c, d, e). Polian vessel and madreporal canal, single. The genitalia consist of numerous comparatively short unbranched coeca, springing from each side of the genital duct, for a distance of about 30 mm.; in the type they contain ova, and are of a bright yellow colour.

The body colour of the animal is a brownish pink; tube feet, white; tentacles, black. In life, it covers itself with stones, shells and shore debris.

This Holothurian is of frequent occurrence along our coast line, though its habit of coating itself with debris would often protect it from observation. The strong dorsal flexure invariably noted in all spirit specimens of this genus, would appear to be a post mortem contraction, as I have, in this species at least, never seen it in life; the animal simply adheres and accommodates itself to the surface to which it may be attached.

GENUS COLOCHIRUS.

COLOCHIRUS SPINOSUS (Quoy and Gaimard).

For synonymy, see

Theel (19), and

1897. Whitelegge (20), Colochirus spinosus.

There are five typical specimens of this species in the collection of the National Museum, Melbourne. They are presumed to have been collected in Victorian waters, but exactly when and where is not indicated. Whitelegge (20) records the animal from Port Jackson, N.S.W.

Colochirus doliolum (Pallas).

For localities and synonymy, see
Erwe Willy (8).

Young specimens of this *Colochirus* are frequently found from the shore down to about five or ten fathoms. Their spiculation exactly agrees with the mature form, but the dark, brown, pigmented areas, which occur in the older animals, are only represented by very faint yellow bands, which rapidly lose their colour in spirits.

GENUS PSOLIDIUM.

Psolidium convergens Perrier.

1905. Perrier R. (18), Psolidium convergens.

Locality.—Flinders.

I secured three specimens of this apparently rare species at Flinders; they agreed well with Perrier's description (18).

GENUS CAUDINA.

Caudina chilensis (J. Muller).

For synonymy, see
Clark (3).

Localities.—Westernport Bay, Mordialloc.

The above localities furnished two specimens which, though differing widely in appearance, I assign to this species. The larger, picked up after a storm at Mordialloc, measures 100 × 40 mm.; it tapers sharply posteriorly, but cannot be described as caudate, colour yellow, blotched with brownish pink; the spicules are more massive than those typical of *chilensis*, the holes being smaller, and the cross being frequently lost by fusion with the disc. The whole ossicle seems to have undergone a process of hypertrophy.

The other specimen, from Westernport Bay, is fairly typical. Some temptation existed to regard these two specimens as belonging to distinct species, but fortunately the writer has recently had an opportunity of examining a collection of over forty speci-

mens of *chilensis*, from the South Australian Public Museum, in which numerous gradations between the typical form and that above described are recognisable.

GENUS LEPTOSYNAPTA.

Leptosynapta dolabrifera (Stimpson).

For synonymy, see

Clark (3).

Localities.—Port Phillip Bay, Westernport Bay, Wilson's Promontory, Torquay, Corio Bay, Flinders.

The species is common. I have met with it from low water mark down to twenty fathoms. There is no doubt in my mind that if *dolabrifera* was collected at a locality north of the equator, it would be identified without hesitation as *inhaerens*. The only slight, but fairly constant difference, that I could detect, was in the width of the anchor plates, which in *dolabrifera* are slightly narrower. The calcareous ring may be quite without neural perforations, or it may have any number up to five. The colour may vary from rose to white, and one specimen from Wilson's Promontory was a deep purple black.

Chiridota gigas Dendy.

Localities.—Wilson's Promontory, Torquay.

There is one specimen in the Museum collection. This was collected by Mr. Kershaw, at Wilson's Promontory; it is very considerably contracted, measuring 70 mm. by 15 mm., the integument being much wrinkled transversely, and quite opate. Mr. Roebuck has twice met with the animal at Torquay. On the last occasion he collected six specimens on a far outlying reef, which is exposed only on the occasion of an exceptionally low tide. He gave me two excellent specimens, one of which, in spirits, measures 15 cm. in length. Mr. Roebuck describes the animal in life as being of very handsome appearance, bright scarlet in colour, with dense, white, prominent papilae. A large specimen is capable of extending itself to a length of from eighteen inches to two feet. When handled, they are very prone to separate themselves into two or three pieces. The description of Dendy and Hindle (5) rendered the identification easy, but the difference of the spacing of the radial muscles, noticed by these authors, cannot, I think, be regarded as a constant character.

I found that it varied not only in different specimens, but in different areas of the same individual. In some cases one of the muscles would be divided in two for some part of its length; I think that both this and the other condition referred to must be assigned to the state of contraction of the circular muscles. The arrangement of the wheel papilae is subject to variation; they frequently occur in all the radii. The polian vessels were very numerous and variable in size in the animals I opened.

CHIRIDOTA INGENS, sp. n.

See Hall (9).

Dr. Hall very kindly placed at my disposal a slide containing the *Chiridota* spicule, referred to in the above paper. It has been presumed to be a tertiary fossil, and I am inclined to think rightly so. The wheel is exceptionally large, 200 μ in diameter, and of the usual Chiridota character. Although collected from a situation in close proximity to the sea, it differs from the ossicle peculiar to the two Chiridotidae, found in the locality, viz., *C. gigas*, and *T. roebucki;* the wheels of the former average 112 μ in diameter, and of the latter, 80 μ. In view of the circumstances under which it was found, I propose regarding the species as new. Hall's figure conveys a good idea of the structure of the spicule.

GENUS TROCHODOTA.

TROCHODOTA ALLANI (Joshua). (Plate I., Fig. 3).

Taeniogyrus allani Joshua (11).

Chiridota allani Dendy (7).

Localities.—Port Phillip Bay, Westernport Bay, Corio Bay.

This species is extraordinarily abundant on the sludge banks which form the greater part of the bottom of Port Phillip Bay. I have seen the dredge presenting the appearance of having been dragged through a mass of blood slime, from the thousands of this species adhering to it. Accompanying it, usually, are about one per cent. of *Leptosynapta dolabrifera.*

Professor Dendy very kindly compared specimens of this animal with those of *Chiridota dunedinensis* Parker, with which it was at one time thought to be identical, and was able to confirm the differences I pointed out in my original description of the species.

(II.) For reasons given in my note on Taxonomy elsewhere, I have abandoned my recognition of *Taeniogyrus* as a genus, and now assign this species to Ludwig's *Trochodota.*

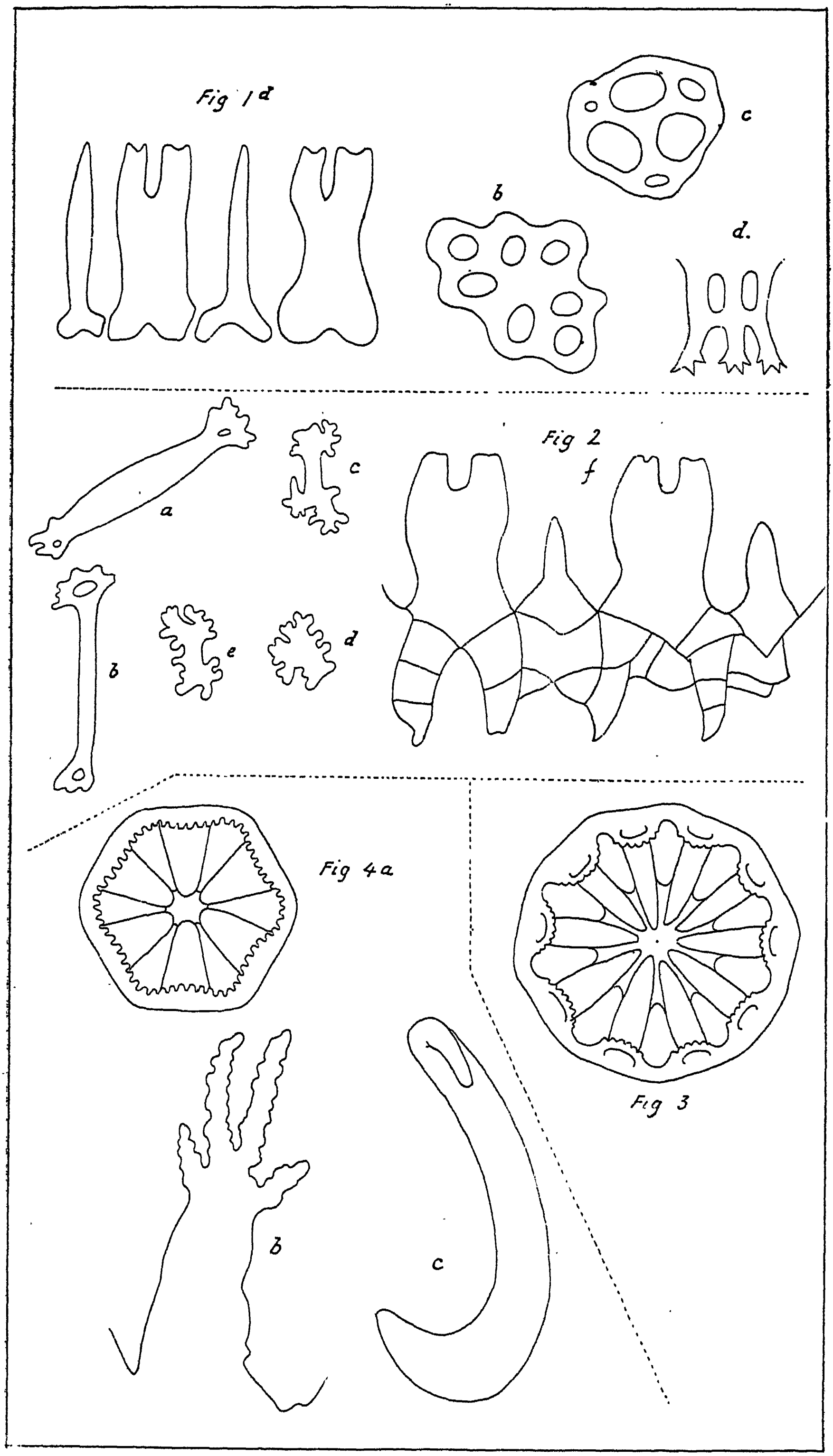
Fig 1 a
b
c
d.
a
c
b
e
d
Fig 2
f
Fig 4 a
b
c
Fig 3

It is perhaps worth noting that *allani* frequently possesses wheels having more than six spokes. A figure of one showing 9 spokes is given. (Fig. 3).

TROCHODOTA ROEBUCKI, sp. n. (Plate I., Figs 4 (a), (b), (c).)

Locality.—Torquay.

Length 75 mm., breadth 6mm.; vermiform; colour, red. Ten tentacles, the two ventral of which are about half the length of the dorsal. Each tentacle has but four digitations, the two proximal of which are about one-third of the length of the distal. Deposits of two kinds, consisting of wheels measuring 80 μ in diameter, and sigmoid bodies (Figs. 4 a and c), 130 μ in length. The wheels have six spokes; the rim is hexagonal, its inner margin is coarsely serrated around its whole circumference. The sexes are apparently separate. The genital glands are unbranched. There is a single polian vessel, and one madreporal canal, which is fused to the dorsal mesentery. Mr. Roebuck collected several specimens from beneath stones at Torquay, and I have since met with them in the same locality. The animal would appear to be very close to the European species, *Trochodota venusta*, Semon. However, the proportion of the digitations on the tentacles and the form of the wheel ossicles differ from the illustrations of these structures, given respectively by Clark (3) and Ludwig (16) for *venusta*. I have, unfortunately, been unable to refer to Semon's original paper. The variation in the size of the tentacles is quite constant, and has been determined by the examination of numerous specimens, both in a living and preserved condition. They increase gradually in size from the venter to the dorsum.

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DESCRIPTION OF PLATE.

Fig. 1.—*Cucumaria mutans*, sp. n.
- a, calcareous ring, enlarged.
- b, c, d, ossicles from perisome × 300.

Fig. 2.—*Phyllophorus vestiens*, sp. n.
- a, b, rods from tentacles × 300
- c, d, e, small bodies from tentacles × 400
- f, calcareous ring, enlarged.

Fig. 3.—Abnormal ossicle from *Trochodota allani* (Joshua) × 300.

Fig. 4.—*Trochodota roebucki*, sp. n.
- a, wheel ossicle × 300.
- b, tentacle, enlarged.
- c, sigmoid ossicle × 300.

[PROC. ROY. SOC. VICTORIA, 27 (N.S)., PT. I., 1914].

ART. II.—*Notes on Australian Cicadidae.*

BY HOWARD ASHTON.

(With Plate II.).

[Read 14th May, 1914].

Of the cicadas described below, two belong to the distinctively Australian genus *Macrotristria*, and come from Northern Australia, having been given to me by Mr. Chas. French, junr, Government Entomologist. One of them is remarkable for its resemblance to *Thopha Sessiliba*, Dist. so closely resembling it in general appearance that it might even be mistaken on a passing glance. The other is not remarkable in any way except for its almost uniform chestnut colour. In this it resembles *M. nigrosignata*, Dist., but it is distinct from this species in its more sessile eyes, its narrower thorax, and the lack of the black basal area and membrane to the tegmina. I have named it after Mr. French. The other two belong to the genus *Psaltoda*, one of them coming from Lord Howe Island.

Sub-family CICADINAE.

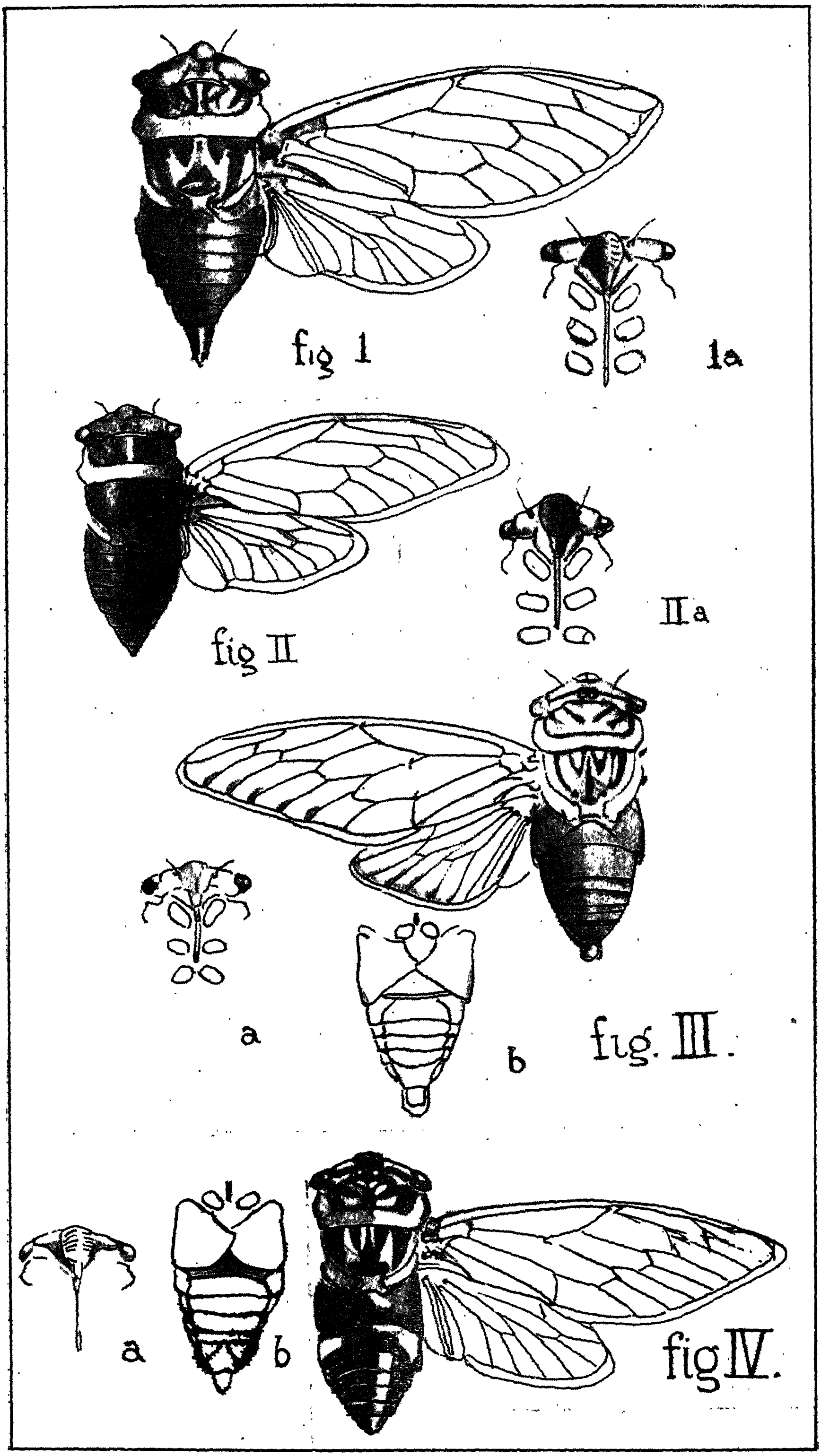
Division CICADARIA.

Genus MACROTRISTRIA, Stäl.

M. FRENCHI, n. sp.

Head deep, reddish-yellow, ocelli surrounded by black, two castaneous spots at base of front.

Pronotum light castaneous, obscure yellowish central longitudinal fascia, posteror margin broad, bright yellow. *Mesonotum* very deep castaneous, with cruciform elevation and posterior margins dull ochraceous. *Abdomen* deep castaneous, shading to black, penultimate segment margined posteriorly with dull yellow. *Tegmina* vitreous, costa and basal cell pale bright yellow, basal membrane orange-red, venation from light fuscous at base to dark fuscous at apex. *Wings* vitreous, venation yellow at base, pale fuscous at apex. Body beneath black, face, legs and rostrum cas-



Howard Ashton del.

taneous. Space between face and eyes yellow. Abdominal segments shining black, margined with dull ochraceous.

Length.—34 mm., exp. teg. 105 mm.

Hab.—Catherine River, N. Territory, S. Australia.

M. THOPHOIDES, n. sp.

Head and thorax ochraceous. *Head* a little reddish. *Pronotum* with two central longitudinal lines (enclosing a yellow streak), incisures, anterior border of posterior margin, castaneous, posterior margin very broad, stramineous. *Mesonotum* with two short central obconical spots, two longer outer fascia, and the area before the cruciform elevation castaneous. *Abdomen* castaneous. *Tegmina* with costa stramineous, posterior edge and other venation, except ulna castaneous, basal cell deeply and opaquely castaneous, basal membrane ochraceous. Anastomoses to apical areas very faintly infuscated, and traces of suffusion about apices of longitudinal veins to these areas. *Wings* with venation stramineous. Body beneath light castaneous, except for head, which is reddish-yellow. Face prominent, reddish-yellow. *Rostrum* castaneous, darker at tip, reaching hind coxae. The eyes are very sessile, and the head very short above. The species, except for its red and yellow colouration, resembles *M. angularis*, Germ., more than any other of its genus. The wing tips of the specimen are mutilated.

Length.—41 mm.; exp. teg., circ. 120-124 mm.

Hab.—Norseman, W. Australia.

Allied to *M. godingi*, Dist.

Division CYCLOCHILARIA.

Genus PSALTODA, Stäl.

PSALTODA ADONIS, n. sp.

Head and thorax green, abdomen brownish luteous. Head, with base of front, narrow fascia between eyes, and region of ocelli black, eyes dark brown, ocelli close together, pale red. *Pronotum* with incisures, inner border of anterior margin, inner and outer borders of posterior margins black. *Mesonotum* with two short central obconical spots yellowish, margined with black, two longer obconical black spots outside these, inwardly excavated with yellowish-green, a central lanceolate line, and two rounded spots at anterior

angles of cruciform elevation, black. Abdomen deep brownish, somewhat luteous, with darker bands on apical segmental margins. Tegmina vitreous, costa green on basal half, thence deep brown. Other venation brown, with apical veins narrowly infuscated and veins at the bases of second and third apical areas deeply and broadly margined with fuscous. Wings with apical veins narrowly fuscously margined. Head beneath with lateral striae, and central sulcus to face black, legs green, with fore and intermediate tibiae and tarsi brown, opercula broad, brown, overlapping at centre, oblique at hind margins, rostrum barely reaching hind coxae.

Length.—37 mm.; exp. teg. 114 mm.

Hab.—Blackbutt, Queensland.

Allied to *P. fumipennis*, Ashton, from which it may be clearly distinguished by the different marking of tegmina and wings, the greater size, the more convex front to head, and the very oblique, angular opercula.

PSALTODA INSULARIS, n. sp.

Head pale yellow; base of front, whole of vertex, and broad fascia from eyes through vertex, black. *Pronotum* black, anterior marginal transverse fascia, followed by two oblique spots, a narrow central fascia and two large triangular discal spots, pale yellow. Posterior margin pale yellow. Mesonotum pale yellow, two central obconical spots, the apices of which unite with the lateral angles of a broad central lanceolate spot, which then occupies the whole space before cruciform elevation, and two broader exterior obconical fasciae, black. *Abdomen* shiny black, two patches of silvery tomentum one on each side of second segment. Body beneath yellowish-white, streaks to femora and fore tibiae black, rostrum black, reaching hind coxae. Opercula outwardly oblique, rounded posteriorly. *Tegmina* and wings vitreous, immaculate, venation near base yellowish, outwardly fuscous.

Length, 26 mm., exp. teg. 76 mm.

Hab.—Lord Howe Island.

Allied to *P. harrisii*, Leach.

DESCRIPTION OF PLATE.

Fig. 1.—*Macrotristria thophordes*, n. sp. Natural size.
Fig. 2.—*Macrotristria frenchi*, n. sp. Natural size.
Fig. 3.—*Psaltoda adonis*, n. sp. Natural size.
Fig. 4.—*Psaltoda insularis*, n. sp. × 3.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PT. I., 1914].

ART. III.—*Three New African Cicadas.*

BY HOWARD ASHTON.

(With Plate III.)

[Read 14th May, 1914].

All these species come from Central Africa, and all belong to the dominant African genus *Platypleura*. The first one, *P. nigromarginata*, is distinguished by its immensely dilated pronotal angles, being allied to Butler's *P. quadraticollis*, but differing in the lighter colour of the head and thorax, and the generally yellow venation of wings and tegmina. It is also smaller than Butler's species.

The second species, *P. sikumba*, is the smallest of this genus, I think, so far recorded from Africa. It is a very distinct little species, being placed in Distant's divison of the genus, in which the tegmina and wings are wholly opaque. The only hyaline or transparent portions are the first discoidal and a small spot in the second discoidal areas, a postcostal spot in the radial area, a fascia extending along the basal halves of apical areas, except the seventh, some minute spots at the extreme apices of these areas, and the tegminal and wing margins. The general effect of the tegmina is of a broad fuscous wing, with two transparent fasciae running diagonally along the apical half.

The third species, *P. longirostris*, is closely allied to *P. adouma*, Dist., but may be at once distinguished by the yellow colouration of the wings. It somewhat resembles Walker's *P. signifera*, but differs by the fact that its tegmina and wings have no transparent spots, and that the margins, which are very narrow, are coloured right to the edge. The rostrum, also, is very much longer.

The genus *Platypleura*, besides being widely distributed over Africa, Asia, Malaysia, and the Philippines, has been recorded by Mr. W. W. Froggatt, from Northern Australia, a typical species having been taken by Mr. J. O. Tepper, and named after him.

Sub-family CICADINAE.

Division POLYNEURARIA.

Gen. PLATYPLEURA, Am. and Serv.

P. NIGROMARGINATA, n. sp.

Male.—*Head*, ochraceous, with a faint tint of green. Eyes brown, ocelli red, a slender broken black fascia between eyes, passing through region of ocelli. *Pronotum*, ochraceous, faintly greenish, central tranverse fascia on anterior margin, and margins of posterior marginal area black, with broad black margins to the strongly produced lateral processes, enclosing a triangular spot on each of these produced areas. *Mesonotum* shining chocolate brown, two comma-shaped spots in centre of anterior margin, and a transverse spot, anteriorly obtusely angled in the depression before the cruciform elevation, black. Cruciform elevation with broad flattened disc, light yellowish olive. *Abdomen* shining black, sparsely greyishly pilose, with obscure central dorsal castaneous fascia, final segment brown, tip black. Head beneath obscurely ochraceous, frontal rugae castaneous, central frontal sulcus, two large spots between eyes and front, and two converging fasciae beside clypeus, black. Sternum ochraceous, marked with black, heavily pilose, pronotal lateral margins same as above, legs castaneous, with joints yellow. Abdomen beneath dull ochraceous, with central broad black longitudinal fascia. Opercula translucent brown. *Tegmina and wings* hyaline, venation ochraceous, a little fuscous at apices, slight infuscations about tegminal apical areas, including bases of same and a series of faint spots on ends of longitudinal veins. Anal areas of wings a little dusky. Head very short, not half as long as pronotum, as wide (including eyes), as pronotum and mesonotum (excluding pronotal margins), front depressed, not seen from above, flattened below, deeply centrally sulcate and laterally carinate. Rostrum yellow, darker at tip, just passing hind coxae. Opercula very square, just touching in centre.

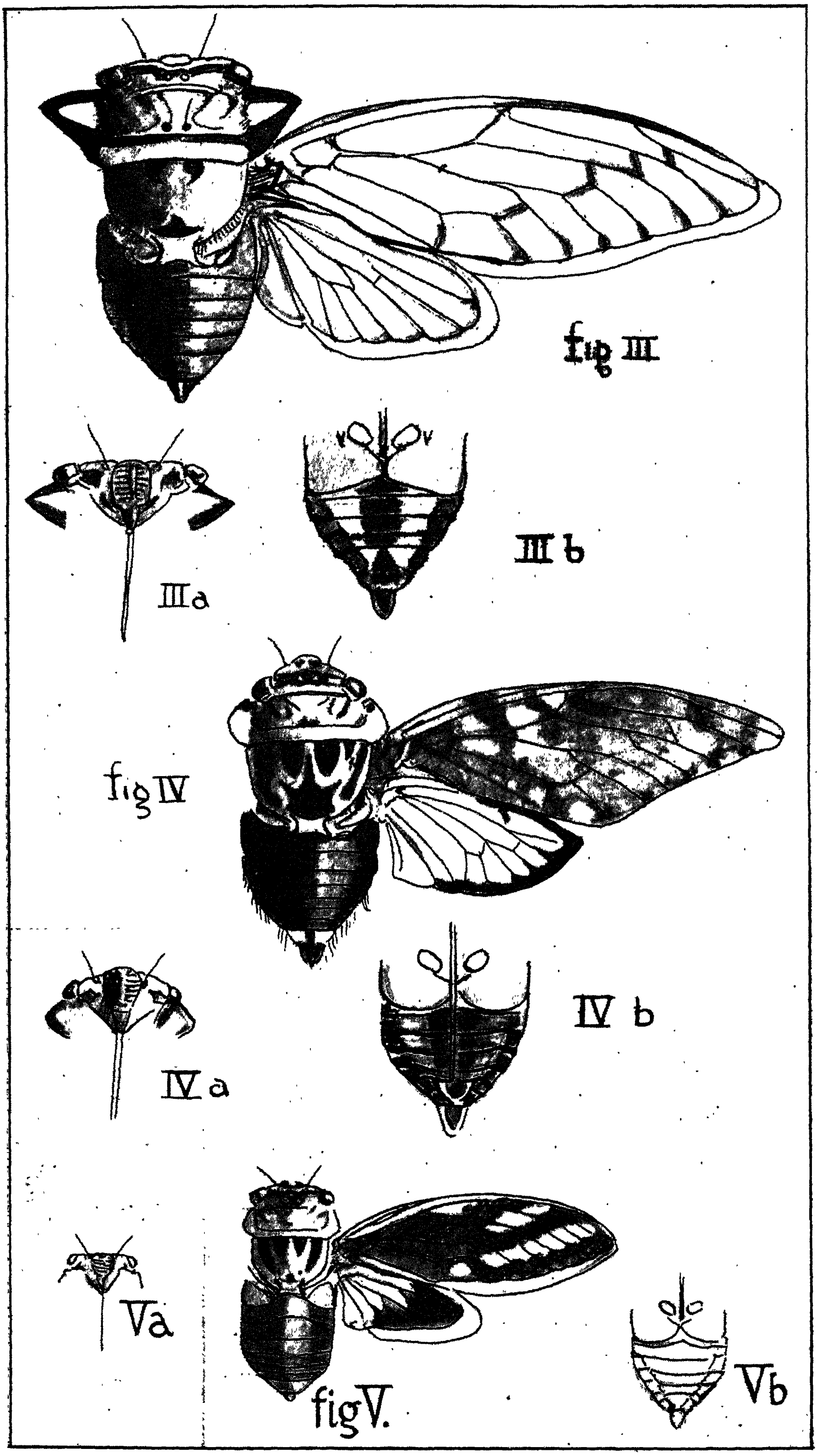
1 male in Coll., H. A.

Length—24 mm.; exp. teg., 80 mm.

Hab.—Africa, Entebbe, Uganda.

PLATYPLEURA SIKUMBA, n. sp.

Head brownish ochraceous, two black fasciae between eyes, one pasing through base of front, the other across region of ocelli,



Howard Ashton del.

Eyes brown. *Pronotum.* brownish ochraceous, immaculate. *Mesonotum.* brownish ochraceous, with four strongly defined black obconical spots, the inner pair shorter, brownish spots at anterior angles of and on centre of disc of cruciform elevation. Abdomen black, shading at lateral edges and tip to an obscure castaneous. Body beneath brownish ochraceous. *Tegmina* all greyish fuscous and opaque, except for a hyaline fascia across bases of apical areas, and another, including upper discoidal area and portion of second. Spot behind costa, small spots in apices of apical areas, and margin, also hyaline. *Wings* with basal third and anal area yellow, central third deep fuscous, and apical margin, which is very broad, hyaline. Head equal in width to mesonotum, short, obtusely convex, front not prominent, pronotal margins narrow and not produced laterally; head, pronotum and mesonotum about equal in length to abdomen. Face flattened, rostrum just reaching hind coxae. Opercula, broadly rounded posteriorly, not quite meeting centrally. Seven males in Coll. H. A..

Length.—13-15 mm.; exp. teg., 37-40 mm.

Hab.—Central Africa, Sikumba.

Platypleura longirostris, n. sp.

Head, dull ochraceous, base of front in two bright yellow spots, followed by a fine black fascia. Black fascia between eyes, including area of ocelli and broken between ocelli and eyes, and surround a dull ochraceous spot. Eyes brown. *Pronotum* dull ochraceous, incisures and spot before posterior margin blackish. Spot on anterior angles of pronotal lateral margins, which are fairly ampliate and rounded, black. *Mesonotum* ochraceous, two central obconical spots, on each side a longer fascia extending over almost whole of lateral areas, between the two central spots a fine line joining with a large black area before the cruciform elevation; all black, cruciform elevation shining yellow. *Abdomen* black, tympanal coverings dull castaneous, penultimate segment of abdomen above covered, except for central dorsal line, with white tomentum. *Tegmina* warm fuscous, marked with several white spots, of which the most prominent are, two in radial area, one in third discoidal area, one in eighth apical area, and one at apex of fifth apical area. *Wings* reddish yellow, evenly margined with piceous, white spot on margin just outside anal area, which is all yellow. Body beneath almost uniformly dull brown, central sulcus to face, tip of rostrum,

transverse fasciae on abdominal segments, markings to fore femora, black, sternum and abdomen powdered with white tomentum. Rostrum reaches penultimate abdominal segment. Opercula broad, rounded, just touching centrally. Three males and two females in Coll. H. A.

Length.—♂ 22 mm., exp. teg., 64 mm.

Hab.—Africa, Entebbe, Uganda.

DESCRIPTION OF PLATE.

Fig. 3.—*Platypleura nigromarginata*, n. sp. × 2.
Fig. 4.—*Platypleura longirostris*, n. sp. × 2.
Fig. 5.—*Platypleura sikumba*, n. sp. × 2.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PT. I., 1914].

ART. IV.—*The Anatomy of Caryodes dufresnyi, Leach.*

BY OLIVE B. DAVIES, M.Sc.

(Government Research Scholar, Melbourne University).

(With Plate IV.).

[Read 14th May, 1914].

Introduction.

Most of the specimens with which this work was carried out were collected by Mr. C. French, at Port Esperance, N.W. Tasmania, and sent to Mr. Kershaw, at the National Muesum, who kindly gave them to me to work out their anatomy.

Two other specimens, one of which was immature, were collected by Miss Raff, M.Sc., at Mount Wellington, Tasmania.

Caryodes dufresnyi was named and first described by Leach as a Helix; Zoological Miscellany, vol. 2, pp. 153, 154, pl. 120.

A short account of the anatomy, mostly of the reproductive system, has been given by Semper, in Reis. im Philip., vol. iii. p. 102, pl. xvi., f. 7.

Mr. C. Hedley, F.L.S., has given us a description and a figure in the Proc. Linn. Soc., N.S.W. (2), vi., 1891, p. 19, pl. ii., f. 1a, pl. iii., f.1; and some further information as to its systematic position in the Rec. Austr. Mus., ii. 1892, p. 29.

Other descriptions, chiefly of the shell, have been given by Quoy and Gaimard, in the Voyage of the Astrolabe, vol. ii., pl. x., f.1; and by Adams, in the Genera of Recent Mollusca, vol. 2, pp. 146 and 153.

After having been described by Leach as a Helix, *Caryodes dufresnyi* was described as *Bulimus dufresnyi*. The genus *Bulimus* according to Cox, possesses the following characteristics:—"Shell oblong or turreted, aperture with unequal longitudinal margins, toothless or dentate; columella entire, revolute externally or simple; peristome simple or expanded." While Semper adds:—"A parallel ridged jaw. Teeth similar, in straight or curved rows. Shell long, with thick mouth edge. The kidney is, in spite of the long lung, as short as the pericardium; it is three cornered.

genital organs are quite simple, without accessory organs; there may be a flagellum."

The genus *Caryodes* possesses the following characters, as given by Semper :—" Foot as usual, on the left of the edge of the mantle there is a neck fold. There is a very peculiarly-structured accessory gland to the sheath (Scheide) (homologous to dart sac). Jaw smooth. Teeth all unicuspid (as in Acavus).

" For the characters of the shell, see Albers."

External Features and General Description.

As I was unable to procure any living speciments of *Caryodes dufresnyi*, I had to take the following description and measurements from preserved animals.

Shell: Height, 37 mms.; greatest diameter, 12 mms. Mouth Opening: Height, 10.5 mms.; width, 6 mms. Whorls, 5. Colour brown or brownish green, with darker brown and yellow bands. There is no umbilicus.

The foot of an average specimen, preserved in spirit, measured 25 mm. in length. The animal itself was greyish brown, with a lighter grey colour along the sole of the foot.

Organs of the Mantle Cavity.

The Mantle cavity is very long and narrow; the kidney and heart are situated at the posterior end of it; the blood vessels are large and well marked.

The Kidney is a somewhat triangular organ, with a depression on one side, into which the heart is fitted, and its apex directed forwards. Arising from the apex is a bladder-like structure, which runs backwards, down one side of the kidney and partly round its base, to open about half way along this into the pulmonary chamber.

The Heart. The auricle is rather large compared with the ventricle. It is extremely thin, being little more than a membranous sac. The ventricle has thick walls and a small lumen. The heart is surrounded by the pericardium, an extremely thin membrane, in some places very difficult to make out in the sections.

The Renopericardial canal can be seen very distinctly in section, one of which is represented in Fig. III. It is a short canal leading from the pericardial cavity into the kidney; the canal is lined along along its length by very definite, ciliated, columnar cells.

The Reproductive System.

The Hermaphrodite gland lies close to the internal surface of the third coil of the visceral mass. It is a rosette shaped gland, composed of a number of finger-like processes united at the centre of the gland.

The Hermaphrodite duct is a sinuous duct running from the hermaphrodite gland to the albumen gland. It leaves the hermaphrodite gland from about its centre and runs to near the anterior end of the albumen gland, turns back, lying closely applied to the gland, and enters it about its centre on the under surface.

The Albumen gland is a large compact gland lying behind and partly under the mantle cavity. It is incompletely divided by deep furrows, which give it the appearance of being somewhat lobed.

The Common duct leaves the albumen gland from its anterior end, and passes forwards, where it divides into vas deferens and oviduct.

The Vas deferens is a long slender tube, which, on leaving the common duct, passes round and under a peculiar gland, which I shall call the shell gland, and the oviduct, up to the anterior end, where it then turns and runs backwards, to enter the penis on the under surface at the posterior end.

The Penis is large and strongly muscular. At the posterior end the retractor penis muscle connects it with the body wall. It opens to the exterior beside the female opening.

The Oviduct is a broad tube leading from the common duct to the exterior. Shortly after leaving the common duct, the oviduct receives the opening of a large wide gland, which appears to function as a shell gland.

The gland which I heard call the shell gland is a large thick-walled gland, receiving the duct of the receptaculum seminis, near its anterior end. Internally the lining of the gland is thrown into very large folds, and lying in the grooves between these I found small deposits of calcium carbonate.

This is the structure referred to by Semper as a long thick sac, to the under sheathing of which the uterus and long drawn out receptaculum seminis are placed, and to its base a retractor. This sac cut open contains a sausage shaped body, which is free at the hinder end, and appears rounded at the end; its outer wall was thickly wrinkled and covered with thick epithelium, in the creases of which lay calcium carbonate in irregular plates. He then goes on to give a description of the arrangement of the muscles of this organ.

In transverse section there is seen to be a thin external membrane; underlying this there is a layer of muscular tissue; and lining the lumen of the gland ciliated columnar epithelium, composed of very long narrow cells, very granular at their bases and with many vacuoles. Down one side of the gland is a specially-marked fold, probably the one to which Semper refers. In section this is seen to be composed of muscular tissue, amongst which is scattered some brown material, with no definite structure, and is probably some kind of secretion.

The Receptaculum Seminis is a globular body connected by a long thin duct with the shell gland.

The Alimentary System.

The Jaw is simple and smooth.

The Radula consists of a number of rows of similar unicuspid teeth, one of which is shown in Fig. VIb.

The Mouth opens into a very narrow oesophagus, which is closely surrounded by the salivary glands. The large strong retractor muscles run from either side of the ventral surface of the buccal mass, and uniting, run along the length of the foot. These muscles are of use in the biting and tearing of the food.

The Oesophagus leads into a fairly large stomach, which bends back on itself, so that its anterior end and its posterior end lie side by side. The stomach leads by a long intestine, which twists amongst the liver mass, receiving the ducts from this, and finally ends in the rectum, which runs along the side of the length of the long pulmonary chamber, to open to the exterior at the respiratory opening.

The Salivary glands completely surround the anterior end of the oesphagus, being fused in the mid-dorsal line. Their ducts open into the hinder part of the buccal cavity.

The Liver is a large brown organ occupying by far the larger part of the visceral hump. The intestine passes through it, and receives its ducts near to its anterior end. In it are also embedded the Hermaphrodite gland and the Hermaphrodite duct, while the Albumen gland lies closely fitted into a depression on its ventral surface, being almost completely hidden by it.

The above work was carried out in the Melbourne University, under the direction of Professor Spencer, whom I wish to thank for all his advice. I also wish to thank Mr. J. Brake, B.Sc., who kindly took the photograph represented in Fig. I. for me.

Literature.

Adams.—Genera of Recent Mollusca, vol. ii. pp. 146 and 153.
Cox.—Monograph of Australian Land Mollusca.
Hedley, C., F.L.S.—Proc. Linn. Soc., N.S.W. (2), vi., 1891, p. 19, pl. ii., f. 1a., pl. iii., f.1; Rec. Austr. Mus. ii., 1892, p. 29.
Semper.—Reis. im Philip., vol. iii., p. 102, pl. xvi., f. 7.
Quoy and Gaimard.—Voyage of the Astrolabe, vol. ii., pl. x., f. 1.
Leach.—Zoological Miscellany, vol. ii. pp. 153-154, pl. 120.

EXPLANATION OF PLATES.

In all figures :—

An.	Anus.
A.G.	Albumen gland.
Aur.	Auricle.
B.M.	Buccal mass.
B.V.	Blood vessel.
C.	Cilia.
C.D.	Common duct.
C.G.	Cerebral ganglia.
C.G.A.	Common genital atrium.
H.D.	Hermaphrodite duct.
H.G.	Hermaphrodite gland.
K.	Kidney.
L.	Liver.
M.C.	Mantle cavity.
O.	Oesphagus.
OD.	Oviduct.
P.	Penis.
P.C.	Pericardium.
R.	Rectum.
R.M.	Retractor muscle.
R.P.C.	Renopericardial canal.
R.S.	Receptaculum seminis.
Sa.G.	Salivary gland.
S.G.	Shell gland.
T.S.	Superior tentacle.
V.	Ventricle.
V.D.	Vas deferens.
V.H.	Visceral hump.

Fig. I.—Bulimus dufresnyi (Shell) from a photograph.

Fig. II.—Dissection of Bulimus dufresnyi, to show general position of the organs.

Fig. III.—Section across the Kidney and Heart, showing the Renopericardial canal.

Fig IV.—The Reproductive System.

Fig. V.—The Reproductive System dissected out, to show the course of the vas deferens, and the shell gland.

Fig. VI.—(A) Portion of Radula, showing teeth in position. (B) Single tooth.

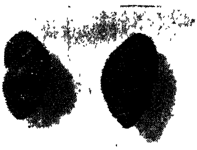


Fig. I.

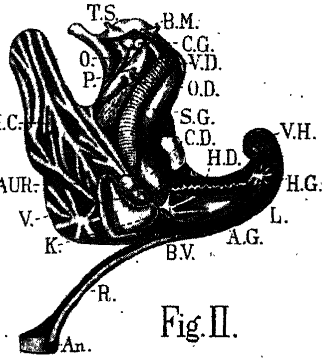


Fig. II.

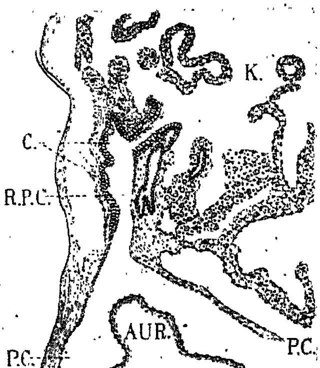


Fig. III.

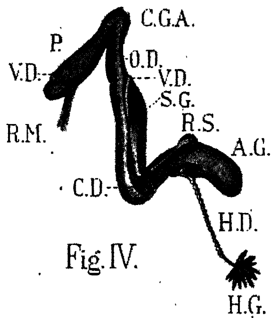


Fig. IV.

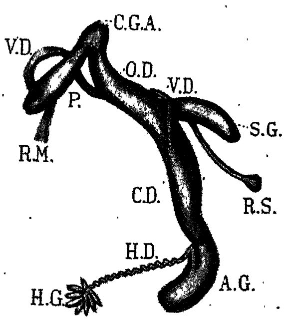


Fig. V.

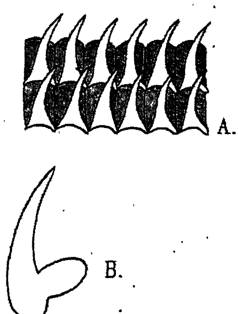


Fig. VI.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.)., PT. I., 1914].

ART. V.—*On a New Species of Ceratodus from the Cretaceous of New South Wales.*

BY FREDERICK CHAPMAN, A.L.S., &c.

(Palaeontologist to the National Museum, Melbourne.)

(With Plate V.).

[Read 14th May, 1914].

Introductory.

The specimen now described is an opalised tooth of *Ceratodus*, from the Upper Cretaceous of Walgett, N.S.W. It was presented to the National Museum by T. C. Wollaston, Esq., of Glenelg, S.A. The external surface of the tooth has been remarkably well preserved during the opalisation process, even to the minutest pittings and rugosities. During replacement, the precious opal has infilled the hollow portions of the tooth with amorphous mineral, but the external part is faithfully replaced, as it still shows, in some places to the depth of 8 mm., the vasodentinal structure as clearly as in a recent tooth of *Ceratodus*. The tooth is somewhat imperfect, having lost approximately 6 mm. of the anterior denticle, and a small flake from the posterior denticle.

Description of *Ceratodus* (*Metaceratodus*)[1] *wollastoni*, subgen. and sp. nov.

This tooth, including a portion of the splenial bone, comes from the right side of the mandible, or lower jaw. It carries four denticles which, in their directly normal arrangement, are like those of the living *Ceratodus* (*Neoceratodus*) *forsteri*, Krefft. The inner border is more strongly convex than in the Jurassic species, *C. avus*, Smith Woodward,[2] but exhibits parallel, longitudinal grooves, as in that form. The grinding surface is nearly flat, or only slightly convex, and shallow sulci extend from between the bases of the denticles nearly along the entire surface to the inner margin. The grinding surface, moreover, is roughened by a regular series

1 New subgenus to include the Australian Mesozoic species. See note at end of paper.

2 Ann. Mag. Nat. Hist., ser. 7, vol. xviii., 1906, pp. 1-3, pl. i., figs. 1a, b. Reprinted in Rec. Geol. Surv. Victoria, vol. ii., pt. 2, 1907, pp. 135-137, pl. xiv.

of small pittings or areolations, the margins of which tend to form a rudely polygonal network. These pittings are much finer and closer than seem to be indicated in the woodcut given by Ameghino, of *Ceratodus iheringi*,[1] from the Upper Cretaceous of Patagonia. The splenial portion at the base projects from the tooth for about 4.5 mm., and is flange-like. At the junction of the tooth with the splenial, the lower surface is rather deeply excavated.

Dimensions.—Length of tooth when complete, about 35 mm. Length of second anterior denticle from its junction with the base, 6 mm. Length of anterior denticle, approximately 17 mm. when complete. Greatest height of tooth as distinct from the splenial bone, 10 mm.

Occurrence.—Upper Cretaceous (opal deposits). Walgett. (' Baradine, New South Wales. Collected and presented by T. C. Wollaston, Esq.

Relationships.—A British form, *Ceratodus disauris*, Agassiz,[2] from the Rhaetic of Aust Cliff, shows, in the figure given by L. C. Miall,[3] four denticles, as in the present species. The denticles in the specimen mentioned, however, are more trenchant than in the present species.

Ceratodus avus, Smith Woodward,[4] shows a nearer relationship than other described forms, in having four denticles, and in these being comparatively short.

An Upper Cretaceous species from Patagonia, *C. iheringi*, Ameghino,[5] appears to be a palatal tooth. It has more salient denticles, five in number, and, according to Ameghino, shows closer alliance with the European mesozoic species than with the living Australian *C. (Neoceratodus) forsteri*.

Dr. Emile Haug has described a Cretaceous species of *Ceratodus* (*C. africanus*,) from Djoua, near Timassânine, in the Sahara,[6] which differs from the Triassic European examples in the presence of crenulations upon the anterior side of the tooth, and of six ridges instead of five, characters which approach those of the living lung-fish, *Ceratodus (Neoceratodus) forsteri*, of Queensland.

The surface character of the upper portion of the tooth of *C. wollastoni* bears a close resemblance to the recent *Ceratodus*, from

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1 Publ. Univ. La Plata, No. 2, 1904, p. 10, fig. 1.

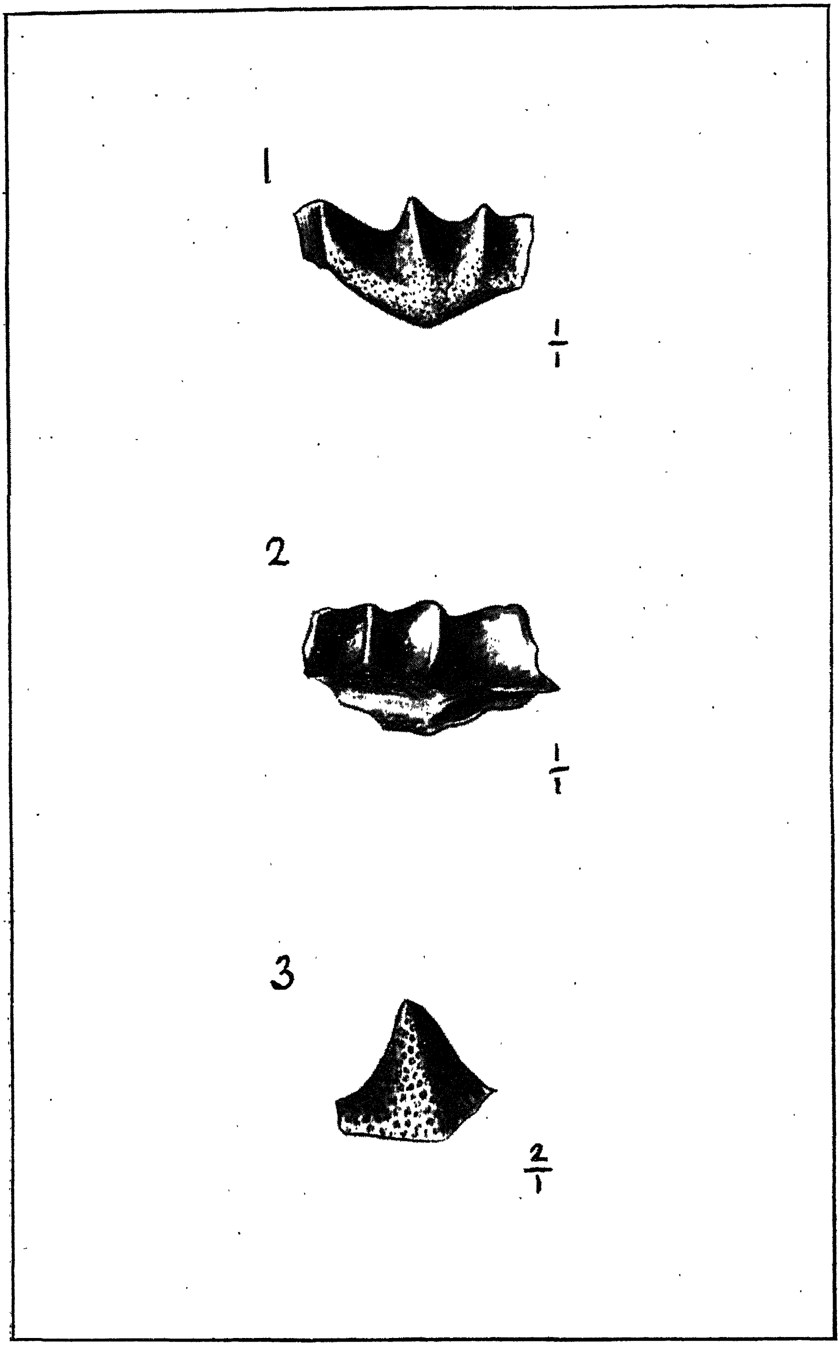
2 Poissons fossiles, Atlas, vol. iii., 1838, pl. xix., fig. 19.

3 See Miall (*Ceratodus parvus*, Miall non Agassiz, fide Woodward and Sherborn, Brit. Foss. Vert., 1890, p. 26), Pal. Soc. Mon., 1878, pl. v., fig. 7.

4 Loc. supra cit., pl. i., figs. 1, 1*a*, *b*.

5 Loc. supra cit., p. 10, fig. 1.

6 C. R. Acad. Sci., Paris, vol. cxxxviii., 1904, p. 1529.



F.C. ad nat. del.

Tooth of Ceratodus (Metaceratodus) wollastoni, sp. nov.
Upper Cretaceous; New South Wales.

which it seems to differ only in the less number of denticles. Regarding this latter feature, Smith Woodward remarks,[1] in speaking of the Jurassic form *C. avus*, which likewise has only four denticles, "The multiplication of the denticles has already been observed in the teeth of certain sharks as they are traced onwards in time; the same phenomenon obviously occurs in *Ceratodus*."

Conclusions.

The occurrence of a tooth of *Ceratodus* in the Upper Cretaceous ... New South Wales helps to link up the fossil Australian species with the living *Ceratodus* (*Neoceratodus*) of Queensland. The older form, *C. avus*, like the present, in showing only four denticles as against six in the living species, bears a close affinity to the Cretaceous species, *C. wollastoni*. On the other hand, the surface of attrition in the Cretaceous tooth has a structure almost identical with the tooth of the living lung-fish, distinguishing it in this respect from the comparatively coarsely reticulated surface seen in the Jurassic species, *Ceratodus avus*.

In consideration of the fact that a fossil scale of *Ceratodus* identical in both form and structure with the living lung fish[2] has been found in the same series of Jurassic strata in Gippsland[3] which contained the tooth of *Ceratodus avus*, the evidence for associating the Jurassic specimen (and at the same time the present Cretaceous form) with both genus and subgenus of the living mudfish, were it not for the number of denticles on the tooth, would seem to be almost conclusive. In view of the intermediate or annectant characters of the Jurassic and Cretaceous with the living species of Australia, the subgeneric name of *Metaceratodus* is here suggested.

EXPLANATION OF PLATES.

Fig. 1.—*Ceratodus* (*Metaceratodus*) *wollastoni*, subgen. et sp. nov. Right mandibular tooth. Upper Cretaceous, Walgett, New South Wales. Nat. size.

Fig. 2.—Ditto. Outer aspect of tooth. Nat. size.

Fig. 3.—Ditto. Denticle enlarged, to show the nature of the pitted outer surface. × 2.

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1 Loc. supra cit., 1906, p. 2.

2 The native name "Barramunda" given to the lung-fish is applied to any large river fish in Queensland, and according to some authorities (see D. G. Stead, "Fishes of Australia," 1906, p. 229), properly belongs to the osteoglossid, *Scleropages leichardti*. The native name "djelleh" especially denotes the lung-fish.

3 Rec. Geol. Surv. Victoria, vol. iii., pt. 2, 1912, p. 234, pl. xxxix.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART I., 1914].

ART. VI.—*Description of New and Rare Fossils obtained by Deep Boring in the Mallee.*

PART III.[1]—OSTRACODA TO FISHES.

With a complete list of Fossils found in the Borings.

BY

FREDERICK CHAPMAN, A.L.S., ETC.

(Palaeontologist to the National Museum).

(With Plates VI.–X.).

[Read 11th June, 1914].

Class CRUSTACEA.

Super-Order OSTRACODA.[2]

Family CYPRIDAE.

Genus ARGILLOECIA, G. O. Sars.

ARGILLOECIA BADIA, G. S. Brady. (Plate VI., Fig. 1).

Argilloecia badia, G. S. Brady, 1880, Rep. Chall., Zoology, vol. i., pt. iii., p. 40, pl. vi., figs 3*a-d*. Egger, 1901, Abhandl, k. bayer. Akad. Wiss., vol xxi., pt. ii., p. 422, pl. iv., figs. 6. 7.

Observations:—

This is the first record of the species in the fossil state. It was described by Dr. Brady from a "Challenger" dredging in 2-10 fathoms at Port Jackson, New South Wales. Dr. Egger also obtained this species from "Gazelle" dredgings off the N.W. coast of Australia at 357 metres; and off the coast of Queensland at 951 metres. Its occurrence in the fossil condition adds to the list of species of Mallee fossils, especially the ostracoda and some

1. For Part II. see this publication, vol. xxvi. (n.s.) pt. ii., 1914, pp. 301-331.

2. The fossil ostracoda of the cainozoics of southern Australia have hitherto been almost entirely neglected. They are therefore here dealt with in more detail than the remaining groups.

foraminifera, still living in the Australian area, but in lower latitudes compared with their miocene ancestors, this obviously pointing to the existence of a warmer climate in those times.

The length of the fossil specimen is .55 mm., whilst the recent example from Port Jackson measured .4mm. Dr. Egger's "Gazelle" specimen measured still less, being .21 mm. in length.

Occurrence.—Bore 5, 189-190 feet (Janjukian).

Genus MACROCYPRIS, G. S. Brady.

MACROCYPRIS DECORA. G. S. Brady sp. (Plate VI., Fig. 2).

Cytherideis decora, G. S. Brady, 1865, Trans. Zool. Soc., Lond., vol. v., p. 366, pl. lvii., figs. 13*a-c*. *Macrocypris decora*, G. S. Brady, 1880, Rep. Chall., Zool., vol. i., pt. iii., p. 44, pl. i., figs. 3*a-d.*; pl. vi., figs. 8*a, b*.

Observations.—

The geographical distribution of this species extends from the West Indies southwards to the Southern Ocean at Kerguelen Id., and thence to the Admiralty Ids.

This species has been recorded[1] in the fossil state under the name of *Paracypris decora*, from the Govt. well-boring in the Murray River Flats, 30 miles N.W. of the Nor'-West Bend of the Murray River. The age of the fossil from that locality is probably Kalimnan (L. Pliocene, "Miocene" of Prof. Tate). The present recorded specimens range from Janjukian to Kalimnan. The Mallee examples approximate to the living specimens in size.

Occurrence.—Bore 9, 256-263 feet; 315-325 feet, Kalimnan or Janjukian). Bore 10, 160-186 feet (Kalimnan). Bore 11, 542-544 feet (Janjukian).

MACROCYPRIS TUMIDA, G. S. Brady. (Plate VI., Fig. 3).

Macrocypris tumida, G. S. Brady, 1880, Rep. Chall., Zool., vol. i., pt. iii., p. 43, pl. vi., figs. 2*a-d*. Egger, 1901, Abhandl. k. bayer. Akad. Wiss., vol xxi., pt. ii., p. 424, pl. i., figs. 27-29.

Observations.—

This species is one of the commonest and most generally distributed in the Kalimnan and Janjukian portion of the present

1. Geol. Mag., Dec. ii., vol. iii., 1876, p. 335 (list). See also ibid, vol. iv., 1877, p. 526, as to the age of the beds.

borings. It varies greatly in the proportional acumination of the post-ventral angle, and may be distinguished from *M. decora* by the evenly-swollen sides and less flexuous upper and lower borders. Dr. Brady gives as original localities for the living specimens, Kerguelen Id., at 28 fathoms, and Wellington Harbour, New Zealand, from the tow-net at trawl. Dr. Egger obtained this species from the north-west coast of Australia, at 357 metres.

Occurrence.—Bore 2, 198-200 feet (Kalimnan). Bore 4, 180-190 feet (Janjukian). Bore 8, 210-219 feet (Kalimnan or Janjukian). Bore 9, 256-263 feet (Kalimnan or Janjukian). Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 457-458 feet; 540-542 feet; 542-544 feet (Janjukian).

Genus BYTHOCYPRIS, G. S. Brady.

BYTHOCYPRIS TUMEFACTA, sp. nov. (Plate VI., Figs. 4*a-c* and 5).

Description.—Carapace subreniform, very tumid. Seen from the side, greatest height about the middle; dorsal margin evenly arched, ventral margin straight to slightly concave, with a faint sinuousity in the middle; extremities rounded, the posterior rather more acutely than the anterior. Left valve much larger than the right, overlapping all round. Seen from above, edge view sub-oblong, anterior end sub-acutely rounded, the posterior bluntly rounded. End view sub-circular, ventral edge flatter than the dorsal. Surface smooth.

Dimensions.—Holotype: Length, 1.125 mm.; breadth of carapace, .575 mm.; height, .575 mm. Paratype: A left valve. Length, .95 mm.; height, .5 mm.

Affinities.—In outline this species is somewhat close to *Bythocypris reniformis*, G. S. Brady,[1] from which it materially differs in its more swollen carapace and less reniform outline. It is interesting to note, in common with the above comparison, that *B. reniformis* is still living in Bass Strait, so that it is very probable that the present species was the direct forerunner of the living Australian form.

Occurrence.—Bore 4, 163-170 feet (Kalimnan or Janjukian). Bore 5, 189-190 feet (Janjukian). Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 342-349 feet; 450-452 feet; 540-542 feet; 546-548 feet; 552-554 feet; 554-556 feet; 556-558 feet; 558-560 feet (Janjukian).

1. Rep. Chall. Zool., vol. i., pt. iii., 1880, p. 46, pl. v., figs. 1*a-l*.

Fam. BAIRDIIDAE.

Genus BAIRDIA, McCoy.

BAIRDIA AMYGDALOIDES, G. S. Brady. (Plate VI., Fig. 6).

Bairdia amygdaloides, G. S. Brady, 1865, Trans. Zool. Soc., Lond., vol. v., p. 364, pl. lvii., figs. 6*a-c*. Idem. 1880, Rep. Chall., Zool., vol. i., pt. iii., p. 54, pl. ix., figs. 5*a-f*; pl. x., figs. 2*a-c*. Chapman, 1910, Proc. Roy. Soc., Vict., vol. xxii (N.S.), pt. ii. p. 307.

Observations.—

The above species has been met with in fossil deposits only once previously, namely, at Batesford, near Geelong, in beds of Janjukian age. In the Mallee bores the continuity of the fossil series with the living form is seen in the fact that examples occur in both Janjukian and Kalimnan beds. The fossil specimens are slightly smaller, but otherwise typical, with the exception that the dorsal margin is rounder and the posterior acumination sulcated, as in *B. victrix*,[1] from which species it differs in its more elongate shape and less strongly arched dorsal margin. It probably points to an ancestral type from which both living forms have diverged through differences in environment.

In the living state *B. amygdaloides* has a fairly wide distribution, for it ranges from the coral islands of the Pacific and Torres Strait to Port Jackson, and even as far south as Moncoeur Id., Bass Strait. Its bathymetrical range is down to 160 fathoms.

Occurrence.—Bore 4, 180-190 feet (Janjukian). Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 542-544 feet (Janjukian).

BAIRDIA AUSTRALIS, sp. nov. (Plate VI., Fig. 7)

Bairdia ovata, G. S. Brady (non Bosquet sp.), 1865, Trans. Zool. Soc., Lond., vol. v., p. 354, pl. lvii., figs. 7*a-c*. Idem, (in R. Etheridge's Report), 1876, Geol. Mag. Dec. ii., vol. iii., p. 335.

Bairdia (?) *ovata*, G. S. Brady (non Bosquet sp.), 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 53, pl. vii., figs. 3*a-d*.

Observations.—As Dr. Brady has already pointed out,[2] the recent specimens from Simon's Bay, South Africa (15-20 fathoms), and from the E. of New Zealand (150 fathoms), differ from

1. G. S. Brady. Ibid, p. 56, pl. x., figs. 5*a-d*.
2. Tom. cit., 1880, p. 54.

Bosquet's Cretaceous fossils in having the carapace higher in proportion to the length, and in having a more acute posterior angle. Bosquet remarks in his description[1] that the valves are obliquely oval and rounded at the two extremities. The feature of a sub-acute posterior angle is so constant in both the Cainozoic and living Australian examples that it necessitates a separation of these forms from the Cretaceous specimens.[2] They may, therefore, appropriately bear the name *Bairdia australis*.

The earlier record of the above species as a fossil is by G. S. Brady (in R. Etheridge, as *B. ovata*, Brady). It came from the Kalimnan deposits (Lower Pliocene) of the Murray River Flats, South Australia.

In the Mallee Bores the above species was obtained from both Janjukian (Miocene) and Kalimnan beds. They are all isolated valves, and thus similar to the living examples dredged by the "Challenger."

Occurrence.—Bore 9, 256-263 feet (Kalimnan or Janjukian). Bore 11, 260-265 feet (Kalimnan). 540-542 feet; 542-544 feet; 548-550 feet; 552-554 feet; 554-556 feet (Janjukian).

Family CYTHERIDAE.

Genus CYTHERE, Müller.

CYTHERE CANALICULATA, Reuss sp. (Plate VI., Fig. 8).

Cypridina canaliculata, Reuss, 1850, Haidinger's Abhandl., vol. iii., p. 76, pl. ix., fig. 12.

Cythere canaliculata, Reuss sp., Egger, 1858, Ostrak. der Miocän.-Schicht., vol. v., p. 33, pl. v., figs. 10, 11. Brady, G. S., 1865, Trans. Zool. Soc., Lond., vol. v., p. 373, pl. lix., figs. 4*a-f*. Idem, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 73, pl. xiv., figs. 7*a-d*. Egger, 1901, Abhandl. d. k. bayer. Akad. Wiss., vol. xxi., Abth. ii., p. 432, pl. iv., figs. 15, 16.

Observations.—This distinct little species has had a world-wide distribution from Miocene times to the present day. Reuss described it from the Cainozoics of Bohemia, Austria (Miocene),

1. Bosquet, Verh. de Comm. Geol. Beschr. Kaart Nederland, vol. ii., 1854, pp. 73 and 74, pl. v., figs. 6*a-d*.

2. For tracings and a copy of the description of Bosquet's Cretaceous record I am indebted to my friend Mr. Chas. Davies Sherborn, A.L.S.

Galicia (Miocene) and Parma (Middle Pliocene). Egger obtained it from the Miocene of Ortenburg. Lienenklaus found the same species in the Middle Oligocene of Jeurre. It has also occurred in Pleistocene deposits in Scotland, as recorded by Brady, Crosskey and Robertson. In Australia its present occurrence as a fossil is in Miocene (Janjukian) strata. In some of the examples found here, the rugosities of the carapace tend to become papillate.

In the living condition *C. canaliculata* was found by Dr. G. S. Brady in dredgings from Hobson's Bay, where the present writer has also found it in abundance, and in no wise differing from Reuss' fossil form. Brady also found it in the "Challenger" dredgings off East Monçoeur Island, Bass Strait, 38-40 fathoms; and in Port Jackson, N.S. Wales, 2-10 fathoms. The example figured by Egger (loc. cit. pl. iv., figs. 15, 16) from the "Gazelle" dredgings, Sta. 90, 18° 52′ S, 116° 13 E, off Western Australia, appears to be identical with Brady's *Cythere foveolata*, which has a broader carapace, and is not so rugosely ornamented.

Occurrence.—Bore 9, 256-263 feet (Kalimnan or Janjukian). Bore 11, 219-260 feet; 260-265 feet (Kalimnan); 446-448 feet; 546-548 feet; 548-550 feet (Janjukian).

CYTHERE CRISPATA, G. S. Brady. (Plate VI.. Fig. 9).

Cythere crispata, G. S. Brady, 1868, Ann. Mag. Nat. Hist., ser. 4, vol. ii., p. 221, pl. xiv., figs. 14, 15. Idem, 1880, Rep. Chall. Zool., vol. i., pt. iii.; p. 72, pl. xiv., figs. 8 *a-d*.

Observations.—The fossil valves from the Mallee bores approach the living specimens very closely, both in form and ornament. The polygonal surface wrinklings are, if anything, slightly coarser in the fossil examples. In some features it approaches both *C. lubbockiana*, G.S.B. and *C. demissa*, G.S.B.

In the fossil condition *C. crispata* has hitherto been known only from the Pleistocene of Scotland, Ireland and Norway. It is a widely distributed form at the present time, being known from the shores of Great Britain, Norway and the Mediterranean; and in the southern hemisphere in Port Jackson (2-10 fathoms), off Booby Islands (6-8 fathoms); and in Hong Kong Harbour (7 fathoms).

This species has been lately recorded by the writer from "Endeavour" dredgings off South Australia at 100 fathoms.

Occurrence.—Bore 11, 544-546 feet; 554-556 feet (Janjukian).

CYTHERE DASYDERMA, G. S. Brady. (Plate VI., Fig. 10).

Cythere dasyderma, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 105, pl. xvii., figs. *4a-f*; pl. xviii., figs. *4a-f*.

Observations.—The living species differs from our fossil examples in having the intersections of the angular excavations beset with short, blunt spines. In the fossils the angular pittings are strongly developed, and it may be surmised that the spines, if any existed, were fine and have been abraded.

C. dasyderma has been recorded by its first describer from 20 widely separated localities, all of which show deposits of a more or less deep sea nature.

Occurrence.—Bore 11, 552-554 feet; 554-556 feet (Janjukian).

CYTHERE DEMISSA, G. S. Brady. (Plate VI., Fig. 11).

Cythere demissa, G. S. Brady, 1868, Ann. Mag. Nat. Hist., ser. 4, vol. ii., p. 180, pl. xii., figs. 1, 2. Idem. 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 66, pl. xii., figs. *1a-j*. Id., 1890, Trans. Roy. Soc., Edin., vol. xxxv., pt. ii., No. 14, p. 497.

Observations.—The fossil specimens exhibit the merest trace of the posterior spines of the border sometimes seen in the living examples. Recent specimens were dredgd from Port Jackson at 2 to 10 fathoms; and from Nouméa, New Caledonia, 2 to 6 fathoms. In the South Sea Islands it occurred between tide-marks.

Occurrence.—Bore 10, 160-186 feet; 225-230 feet (Kalimnan).

CYTHERE DICTYON, G. S. Brady. (Plate VII., Figs. 12, 13).

Cythere dictyon, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 99, pl. xxiv., figs. *1a-y*. Egger, 1901, Abhandl. d. k. bayer. Ak. Wiss., vol. xxi., abth. ii., p. 442, pl. vi., figs. 41-43.

Observations.—It will be seen on reference to the splendid series of figures given by Dr. Brady that this species is very variable, owing to the passage of the aculeated surface in the younger stages into the strongly ribbed and excavated ornament of the older stages. In the senile condition it somewhat resembles *C. normani*, but the latter has a more obliquely truncated antero-dorsal angle.

Brady records this species from many localities, chiefly in deep water, as in the West Indies, off Sydney, and Papua. Egger notes it from Kerguelen Island, and Table Bay, S. Africa.

I have lately found this species in dredgings made by the F.I.S. "Endeavour," from E. of Tasmania at 777 fathoms, and off South Australia at 100 fathoms.

It is very interesting to note that this species is one of the most abundant in the Mallee fossil material, as it is in many deep-water dredgings at the present day. It is, moreover, an almost restricted southern form. The Mallee specimens frequently have their valves united, pointing to tranquillity of the water during the deposition of the calcareous Miocene ooze.

Occurrence.—Bore 1, 215-244 feet (Janjukian). Bore 9, 256-263 feet; 315-325 feet (Kalimnan or Janjukian). Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 219-260 feet; 260-265 feet (Kalimnan); 267-270 feet; 272-315 feet; 438-440 feet; 457-458 feet (Janjukian).

CYTHERE FLEXICOSTATA, sp. nov. (Plate VII., Figs. 14*a*, *b*).

Description.—Valve, seen from the side, elongate, pyriform; broad anteriorly, with a deep flange-like border, highest in the anterior third; ventral and dorsal margins nearly parallel for some distance, but tapering posteriorly to a blunt point; dorsal margin convex, and interrupted by a short crest-like spine, ventral margin straight; the posterior extremity is armed with a few ragged spines. In edge view the valve is thickest in the posterior third, where it terminates in a strong salient spine, falling abruptly and concavely to the posterior, and gradually to the anterior, extremity. Surface of valve ornamented with six or seven longitudinal, sinuous costae, which are more or less persistent from end to end of the valve; they pass over the central boss or tubercle, and increase in strength below and above the median area, being carried over on to the anterior flange, and posteriorly take a sudden bend dorsally, passing steeply down to the blunt, spinous hind margin. Between the costae there are faint pittings or excavations.

Dimensions.—Length of valve, .92 mm.; height, .44 mm.; thickness of carapace, about .6 mm.

Observations.—So far as I can find, there is no described species which shows a decided relationship to the above. The general form suggests a remote resemblance to the genus *Bythocythere*,

but the well-marked anterior border and position of the spines and tubercle suggest an affinity with forms like *Cythere rastromarginata.*

Occurrence.—Bore 10, 310-320 feet (Kalimnan or Janjukian).

CYTHERE LACTEA, G. S. Brady. (Plate VII., Fig. 15).

Cythere lactea, G. S. Brady, 1865, Trans. Zool. Soc., Lond.. vol. v., p. 377, pl. lx., figs. 3*a-c*. Idem, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 91, pl. xxii., figs. 1*a-d*.

Observations.—The present fossil occurrences show this comparatively rare form to have existed as early as the Miocene. Our specimen matches exactly that figured by Dr. Brady from an Australian sounding at 17 fathoms.

Occurrence.—Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 562-564 feet (Janjukian).

CYTHERE LEPRALIOIDES, G. S. Brady. (Plate VII., Fig. 16).

Cythere lepralioides, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 94, pl. xix., figs. 5*a-d*.

Observations.—The Mallee specimens came from a Kalimnan horizon (Lower Pliocene). They are fairly typical as compared with the living form, the specimen here figured being a somewhat extreme variety with an unusually broad posterior extremity. Brady records this species from two localities only, viz., Simon's Bay, S. Africa (15-20 fathoms), and off the Cape of Good Hope (150 fathoms). I have lately determined this species from "Endeavour" dredgings taken east of Tasmania at the exceptional depth of 1122 fathoms.

Occurrence.—Bore 6, 114-150 feet (Kalimnan). Bore 8, 210-219 feet (Kalimnan or Janjukian). Bore 10, 195-225 feet (Kalimnan).

CYTHERE LUBBOCKIANA, G. S. Brady. (Plate VII., Fig. 17).

Cythere lubbockiana, G. S. Brady, 1880, Rep. Chall Zool., vol. i., pt. iii., p. 68, pl. xiv., figs. 6*a-d*.

Observations.—This is a shallow water species in modern deposits, being recorded by Dr. Brady from Booby Island, in 6-8 fathoms.

It occurs in the Mallee bore at a distinctly Janjukian (Miocene) horizon, as well as in samples which have a mixed Janjukian and Kalimnan (Lower Pliocene) fauna.

The fossils differ from the living shells in having the surface-pittings rather more pronounced, otherwise they agree.

Occurrence.—Bore 8, 210-219 feet (Kalimnan or Janjukian). Bore 11, 260-265 feet (Kalimnan); 446-448 feet; 540-542 feet (Janjukian).

CYTHERE MILITARIS, G. S. Brady sp. (Plate VII., Fig. 18).

Cythereis militaris, G. S. Brady, 1866, Trans. Zool. Soc., Lond., vol. v., p. 385, pl. lxi., figs. 9*a-d*.

Cythere clavigera, Idem, 1880, Rep. Chall. Zool., vol i., pt. iii., p. 109, pl. xxiii., figs. 7*a-d*.

Observations.—From an extensive series of valves which I refer to the above form, obtained from dredgings round the Australian coast, I am convinced that *C. militaris*, as figured by Dr. Brady, represents the young form of the later described *C. clavigera*, as Brady himself has suggested.[1]

Several early Cainozoic forms allied to this species have been described by Reuss, Speyer and others, which show it to be one of a related group which has persisted throughout the Cainozoic period.

The figured specimen is an extreme form in which the central hystricated crest is strongly developed, and the margin regularly beset with blunt spines. Others of the fossil specimens are matched by Brady's *C. clavigera*, which come from Port Jackson in New South Wales (2-10 fathoms); whilst an occasional young form agrees with the figure of *C. militaris*, passage forms being found which link up the series. The species is very common in the first of the depths indicated below. This is a glauconitic clay in which this species, together with *C. dictyon*, G.S.B., and other ostracodal shells, form about 15 per cent. of the washings.

Occurrence.—Bore 9, 256-263 feet (Kalimnan or Janjukian). Bore 11, 260-265 feet (Kalimnan); 562-564 feet (Janjukian).

CYTHERE NORMANI, G. S. Brady. (Plate VII., Fig. 19).

Cythere normani, G. S. Brady, 1866, Trans. Zool. Soc., Lond., vol. v., p. 379, pl. lxi., figs. 5*a-d*. Idem, 1880, Rep. Chall. Zool. vol. i., pt. iii., p. 101, pl. xvii., figs. 3*a-d.*; pl. xxvi., figs. 4*a*, *b*.

Observations.—Our specimens closely agree with the figures given by Dr. Brady in his original account of the species, specimens of which were dredged from the Abrolhos Bank, S. Africa. The

1. R. Etheridge, Geol. Mag., Dec. ii., vol. iii., 1876, p. 335.

"Challenger" specimens came from Heard Island in the Southern Ocean, at 150 fathoms. *Cythere normani* was also recorded as a fossil by Dr. Brady, from a well-sinking in the Murray Flats of South Australia,[1] in beds of later Tertiary age. I have lately recorded this species from a raised beach (Pleistocene) on the slopes of Mount Erebus in the Antarctic, from material collected on the Shackleton Expedition.

Occurrence.—Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 444-446 feet; 446-448 feet (Janjukian).

CYTHERE OBTUSALATA, G. S. Brady. (Plate VII., Fig. 20).

Cythere obtusalata, G. S. Brady, 1880, Rep. Chall., Zool., vol. i., pt. iii., p. 91, pl. xii., figs. 1*a-c*.

Observations.—It is interesting to record this striking little species for the first time from a fossil deposit, at an horizon near the junction of the Janjukian and Kalimnan beds.

As a recent species *C. obtusalata* has been recorded from off E. Moncoeur Island, Bass Strait, at 38-40 fathoms, and off the Admiralty Islands at 16-25 fathoms (G. S. Brady). Also from Kerguelen Island at 104 metres; near W. Africa at 677 metres; off Monrovia, W. Africa at 18 metres, and near Mauritius at 411 metres (J. G. Egger).

The fossil specimens are closely comparable with the recent forms figured by Dr. Brady.

Occurrence.—Bore 9, 256-263 feet (Kalimnan or Janjukian). Bore 11, 442-444 feet; 446-448 feet (Janjukian).

CYTHERE OVALIS, G. S. Brady. (Plate VII., Fig. 21).

Cythere ovalis, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 66, pl. xiv., figs. 4*a-d*.

Observations.—This species was originally recorded from recent dredgings off Booby Island, Torres Strait at 6-8 fathoms.

The fossil specimen here figured comes from a Janjukian horizon (Miocene). It is closely comparable with the living form, only slightly differing in the more regular polygonal surface-pittings, and in the absence of short spines at the posterior extremity.

Occurrence.—Bore 11, 267-270 feet (Janjukian).

CYTHERE PARALLELOGRAMMA, G. S. Brady. (Plate VII., Fig. 22).

Cythere parallelogramma, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 82, pl. xv., figs. 1*a*-*e*. Egger, 1901, Abhandl. d. k. bayer. Akad. Wiss., vol. xxi., abth. ii., p. 442, pl. vi., figs. 15, 16.

Observations.—Originally dredged off Prince Edward's Island in the Southern Ocean at 50-150 fathoms, this species has lately been found by the writer in a sounding off Cape Wiles, S. Australia at 100 fathoms. Dr. Egger recorded it from the West African coast, and it has lately occurred as a Pleistocene fossil in the Antarctic.

This species shows a considerable amount of variation, the ornament in some specimens becoming granulate at the intersection of the reticulations, whilst the carapace may be more inflated. It seems to link on to *Cythere wyville-thomsoni* by annectant characters.

Occurrence.—Bore 9, 315-325 feet (Kalimnan or Janjukian). Bore 10, 195-225 feet (Janjukian).

CYTHERE POSTDECLIVIS, sp. nov. (Plate VII., Figs. 23*a*, *b*).

Description.—Shell, seen from the side, oblong ovate, highest in the anterior third, with parallel sides and broad recurved anterior end, which projects towards the ventral margin, and is roundly truncate at the dorsal angle; posterior extremity bluntly acuminate. In edge view, the carapace is tumid, depressed in the median area, steeply falling fore and aft to the extremities, the posterior being deeply impressed, and often with a fossa in the central area. Surface-ornament consisting of cancellated and vermiform depressions, which have a distinct trend in certain parts of the shell, tending to parallelism at the hinder end and the dorsal margin. The muscle-spot area is indicated by a stellate arrangement of the cancellae.

Dimensions.—Length, 1-4 mm.; height, .675 mm.; thickness of carapace, .6 mm.

Observations.—In a general way this species is related to both *C. ovalis* and *C. cancellata*. The ornament, however, is so distinct as to warrant the establishment of a new species. The posterior depression is more marked than in *C. cancellata*. It is one of the commonest forms in the present collection of Mallee ostracoda.

Occurrence.—Bore 3, 201-220 feet (Kalimnan or Janjukian). Bore 8, 210-219 feet (Kalimnan or Janjukian). Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 342-349 feet; 438-440 feet; 440-442 feet; 442-444 feet; 446-448 feet; 457-458 feet; 540-542 feet; 542-544 feet; 544-546 feet; 546-548 feet; 548-550 feet; 564-566 feet (Janjukian).

CYTHERE RASTROMARGINATA, G. S. Brady. (Plate VII., Fig. 24).

Cythere rastromarginata, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 83, pl. xvi., figs. 1*a-d.*; 2*a-d.* Egger, 1901, Abhandl. d. k. bayer. Akad. Wiss., vol. xxi., abth. ii., p. 442, pl. vi., figs., 5-9.

Observations.—The "Challenger" examples came from Bass Strait, and off Honolulu. Egger obtained it between Fiji and Samoa, and from the Western Australian coast.

This is its first occurrence in the fossil state. It occurs in the bores in the Kalimnan (Lower Pliocene) strata, or even below that series. Like several other species of ostracoda occurring in these borings, the form persists in the present Bass Strait fauna, not many miles removed from the site of the old Murray Gulf.

Occurrence.—Bore 8, 210-219 feet (Kalimnan or Janjukian). Bore 11, 170-175 feet; 199-209 feet; 219-260 feet (Kalimnan).

CYTHERE SCABROCUNEATA, G. S. Brady. (Plate VIII., Fig. 25).

Cythere scabrocuneata, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 103, pl. xvii., figs. 5*a-f*; pl. xxiii., figs. 2*a-c*.

Observations.—The figured specimen is a quadrate and coarsely papillate variety of the above species, but it is impossible to separate it from its associated typical examples from the same series, some of which are identical with the living forms. This is another species still living in Bass Strait, having remained persistent in nearly the same area from Janjukian (Miocene) times. It has also been recorded from recent dredgings in the Inland Sea, Japan, and in Wellington Harbour, New Zealand.

Occurrence.—Bore 11, 430-432 feet; 442-444 feet; 444-446 feet; 446-448 feet; 457-458 feet; 544-546 feet; 552-554 feet (Janjukian).

CYTHERE SCINTILLULATA, G. S. Brady. (Plate VIII., Fig. 26).

Cythere scintillulata, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 62, pl. xiv., figs. 3*a-d*.

Observations.—This species is represented by one typical specimen in the bores, at a level showing a mixed Kalimnan (Lower Pliocene) and Janjukian (Miocene) fauna. This is its first occurrence in the fossil state.

C. scintillulata was dredged in the Straits of Magellan by the "Challenger," at 55 fathoms.

Occurrence.—Bore 5, 189-190 (Janjukian).

CYTHERE SCUTIGERA, G. S. Brady. (Plate VIII., Fig. 27).

Cythere scutigera, G. S. Brady, 1868, Les Fonds de la Mer, vol. i., p. 70, pl. viii., figs. 15, 16. Idem, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 109, pl. xxii., figs. 5*a-f*.

Observations.—This species, as represented in the Mallee Bores, shows the general specific characters of the recent species, but is less distinct in the sharper features of the carapace.

Brady has recorded this species from Amboyna, Java and Papua.

Occurrence.—Bore 11, 442-444 feet (Janjukian).

CYTHERE WYVILLE-THOMSONI, G. S. Brady. (Plate VIII., Fig. 28).

Cythere wyville-thomsoni, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 82, pl. xx., figs. 4*a-f*. Egger, 1901, Abhandl. d. k. bayer. Akad. Wiss., vol. xxi. abth. ii., p. 444, pl. vi., figs. 13-14.

Observations.—A single specimen of this form, typical in nearly all its characters with the recent form, but not so spinous at the extremities, and with more parallel sides, occurs in the Janjukian (Miocene) of the Mallee bores.

The "Challenger" obtained it from Heard Island and Kerguelen Island in the Southern Ocean, and in Torres Strait. Egger's "Gazelle" specimens came from the west coast of Africa.

Occurrence.—Bore 10, 310-320 feet (Kalimnan or Janjukian).

Genus KRITHE, Brady, Crosskey and Robertson.

KRITHE EGGERI, sp. nov. (Plate VIII., Figs. 29*a*, *b*).

Description.—Valve, seen from the side, narrow, subreniform, anterior extremity rounded, posterior bluntly pointed at the ventral angle; dorsal margin arched, ventral slightly sinuous. The anterior margin is bordered by a flange of unusual width for this genus. Surface minutely punctate. Edge view of carapace ovate, compressed anteriorly, broad at hinder end.

Dimensions.—Length, .615 mm.; height, .27 mm.; thickness of carapace, .27 mm.

Affinities.—This species is related to *Krithe producta*, G. S. Brady,[1] but is much narrower, and has a conspicuous, flange-like anterior border.

Named in honour of Dr. J. G. Egger, who has already described more than one new species of this genus.

Occurrence.—Bore 11, 260-265 feet (Kalimnan).

Genus LOXOCONCHA, G. O. Sars.

LOXOCONCHA AUSTRALIS, G. S. Brady. (Plate VIII., Fig. 30).

Loxoconcha australis, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 119, pl. xxviii., figs. 5*a*-*f*.; pl. xxix., figs. 3*a*-*d*.

Observations.—The "Challenger" recorded this species from Port Jackson, New South Wales, at 2-10 fathoms, and from Booby Island, Torres Strait, 6-8 fathoms. I have lately obtained it from a sounding east of Tasmania, 777 fathoms, dredged by F.I.S. "Endeavour."

Typical specimens occur in both Janjukian and Kalimnan strata in the bores, showing the species to have been established in Australian seas as early as the Miocene.

Occurrence.—Bore 7, 142 feet 3 inches-155 feet (Kalimnan). Bore 10, 195-225 feet; 225-230 feet (Kalimnan). Bore 11, 444-446 feet (Janjukian).

1. Rep. Chall. Zool., vol. i., pt. iii., 1880, p. 114, pl. xxvii., figs. 1*a*-*j*.

Genus XESTOLEBERIS, G. O. Sars.

Xestoleberis curta, G. S. Brady sp. (Plate VIII., Fig. 31).

(?) *Cytheridea curta*, G. S. Brady, 1865, Trans. Zool. Soc., Lond., vol. v., p. 370, pl. lviii., figs. 7*a*, *b*.

Xestoleberis curta, G. S. Brady sp., 1868, Les Fonds de la Mer, vol. i., p. 79, pl. x., figs. 16-18. Idem, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 126, pl. xxxi., figs. 6*a-d*.

Observations.—The specimen from the bore, at a Kalimnan horizon, is in every way typical.

As a recent species this form occurs in the Southern Ocean at Kerguelen Island; at Port Jackson in New South Wales, at Booby Island, Torres Strait, and in the Pacific Ocean at Honolulu, Fiji, and New Caledonia.

Occurrence.—Bore 10, 225-230 feet (Kalimnan).

Xestoleberis margaritea, G. S. Brady sp. (Plate VIII., Fig. 32).

Cytheridea margaritea, G. S. Brady, 1865, Trans. Zool. Soc., Lond., vol. v., p. 370, pl. lviii., figs. 6*a-d*.

Xestoleberis margaritea, G. S. Brady sp., 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 127, pl. xxx., figs. 2*a-g*. Egger, 1901, Abhandl. d. k. bayer. Akad. Wiss., vol. xxi., abth ii., p. 456, pl. iii. figs. 27-30.

Observations.—This species occurs in the Mallee bores at the top of the Janjukian series, thus showing the specimens to have lived in Miocene times.

In the living condition, *X. margaritea* is known from the Mediterranean and off Booby Island, Torres Strait.

Occurrence.—Bore 11, 267-270 feet (Janjukian).

Xestoleberis variegata, G. S. Brady. (Plate VIII., Fig. 33).

Xestoleberis variegata, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 129, pl. xxxi., figs. 8*a-g*.

Observations.—In the living condition this species has occurred at Cape Verde, Tongatabu, Fiji, Samoa, Funafuti and New Caledonia, in depths varying from shallow water to 1150 fathoms. I have lately found this species in a sounding by F.I.S. "Endeavour," off Cape Wiles, S. Australia, at 100 fathoms.

The present example from the bore came from the top of the Janjukian series (Miocene). It is in every way comparable with recent examples of the species now living in the Southern Ocean at 100, fathoms, even to the distinct variegation of the carapace.

Occurrrence.—Bore 11, 267-270 feet (Janjukian).

Genus CYTHERURA, G. O. Sars.

CYTHERURA CAPILLIFERA, sp. nov. (Plate VIII., Figs. 34*a*, *b*).

Description.—Carapace oblong, compressed anteriorly. Seen from the side, the valve is highest at the posterior third; dorsal margin straight in the middle, and convexly rounded to the extremities; ventral border widely concave; surface gently sloping to the front, swollen and abrupt behind, with a short caudal extremity. Edge view compressed at the anterior, abruptly truncated behind, and steeply incurved to the caudal prolongation. Surface ornamented with fine, sinuous, hair-like lines, especially on the ventral area, generally punctate over the whole surface. Colour patches of organic origin still visible on the valve.

Dimensions.—Length, 1.04 mm.; height, .423 mm.; thickness of carapace, .423 mm.

Affinities.—The nearest allied form to the above appears to be *Cytherura similis*, G. O. Sars,[1] a species found round the shores of Great Britain, and in the Arctic and Scandinavian seas, as well as a Pleistocene fossil of Scotland, Ireland and Norway.

Occurrence.—Bore 11, 175-197 feet (Kalimnan).

CYTHERURA OUYENENSIS, sp. nov. (Plate VIII., Figs. 35*a*, *b*).

Description. —Carapace oblong, medially compressed; seen from the side, rhomboidal, highest towards the front, height exceeding half the length; anterior evenly rounded at the ventral, and truncately so at the dorsal angle; posterior bluntly caudate; dorsal line short and straight, curving steeply to the posterior, ventral margin slightly concave, swelling out towards the posterior extremity, where it suddenly curves inward to meet the blunt termination. Edge view of carapace ovate, compressed in front and bluntly acuminate behind; median area slightly depressed. Shell surface relieved with numerous impressed puncta, encircled by a clear ring; other-

1. See Brady and Norman, Trans. R. Dublin Soc. 1889, vol. iv., ser. ii., p. 203, pl. xviii., figs. 7-9

wise fairly smooth, excepting for a few striae parallel with the ventral and anterior margins.

Dimensions.—Length, .634 mm.; height, .346 mm.; thickness of carapace, .308 mm.

Affinities.—The above species resembles a weak form of *Cytherura rudis*, G. S. Brady,[1] that is, having minute pittings instead of polygonal excavations, and without the faint flexuous ribs of that species. The marked distinction of *Cytherura ouyenensis* in having a more rounded contour separates it from Brady's living species, which came from the Arctic Seas and, doubtfully, from the Straits of Magellan. Since Brady's recorded occurrence, *C. rudis* has been found by the writer in soundings from the Antarctic taken by Capt. J. K. Davis in the "Nimrod" (British Antarctic Expedition, 1907-9). That specimen also showed a polygonal rather than the punctate ornament of the present species.

Occurrence.—Bore 11, 267-270 feet (Janjukian).

Genus CYTHEROPTERON, G. O. Sars.

CYTHEROPTERON BATESFORDIENSE, Chapman. (Plate VIII., Fig. 36).

Cytheropteron batesfordiense, Chapman, 1910, Proc. Roy. Soc., Vict., vol. xxii. (N.S.), pt. ii., p. 300, pl. ii., figs. 7*a-c*.

Observations.—Since the discovery of the originally described specimens in the Batesford Limestone, this species has been found in some abundance in the lower strata of the Mallee bores.

In the original description, I noticed the relationship of this form with *Cytheropteron wellingtoniense*, Brady. There is still another species showing close affinities which occurs fossil in the Cretaceous of Basdorf in Mecklenburg, namely, *C. triangulare*, Reuss sp.[2], a species which also occurs in the Cainozoic (London Clay) of Copenhagen Fields and Piccadilly, London. This species differs in having the alae less salient posteriorly, otherwise, as seen in edge view, the two forms are very similar.

Occurrence.—Bore 2, 211-240 feet (Janjukian). Bore 10, 310-320 feet (Kalimnan or Janjukian). Bore 11, 438-440 feet; 440-442 feet; 442-444 feet; 444-446 feet; 457-458 feet; 548-550 feet (Janjukian).

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1. Ann. Mag. Nat. Hist., ser. 4, vol. ii., 1868, p. 34, pl. v., figs. 15-17. Rep. Chall. Zool., vol. i., pt. iii., 1880, p. 152, pl. xxxii., figs. 3*a-d*.

2. *Cythere triangularis*, Reuss, Zeitschr. d. deutsch. Gesellsch., vol. vii., 1855, p. 279, pl. x. fig. 3. Jones, Mon. Tert. Entom. (Pal. Soc.), 1857, p. 25, pl. vii., fig. 5. *Cytheropteron triangulare* Jones, Mon. Tert. Entom. (Pal. Soc.), 1889, p. 44, pl. ii., figs. 19*a-c*.

CYTHEROPTERON BATESFORDIENSE, Chapman., var. aculeata, var. nov. (Plate VIII., Fig. 37).

Description.—This variety is sufficiently well marked to merit a distinctive name, since it has a more compressed carapace, and a sharp ventral margin. Towards the posterior extremity, the ventral border carries a series of short, strong prickles. The related European cainozoic form, *C. triangulare* sometimes shows very fine aculeations on the ventral edge.

Occurrence.—Bore 11, 453-454 feet (Janjukian).

CYTHEROPTERON POSTUMBONATUM, sp. nov. (Plate VIII., Figs. 38).

Description.—Carapace oblong, compressed at the extremities. Seen from the side, the valve is tumid in the central area, depressed around the margins; anterior extremity with a subangular margin, posterior rounded; surface in anterior third swollen into a pear-shaped inflation, behind which is a deep furrow joining the marginal depressed areas, whilst posteriorly the valve is again inflated, and towards the ventral side this prominence is produced into a short recurved hornlike process. Edge view subovate, compressed at the ends, with the post-ventral process pointing outwards and backwards.

Surface of valve ornamented with numerous obscure pittings and fine parallel striae towards the dorsal margin.

Dimensions.—Length, .5 mm.; height, .21 mm.; thickness of carapace, including the process, circ. .4 mm.

Affinities.—The appearance in the Australian Cainozoic of this modification of a well-defined Cretaceous group of *Cytheroptera* is extremely interesting. *C. postumbonatum* is most closely allied to *C. umbonatum*, Williamson sp.,[1] a well-known member of the English Chalk and Chalk-marl of Norwich, Woolwich, Dover and Charing. The Danish and British variety, *C. umbonatum*, var. *acanthoptera*, Marsson var.[2] from the Island of Rügen, Norfolk, Dunstable and Antrim, is distinguished from the specific form in having a much longer postero-ventral spine and a prickly rather than a punctate

1. *Cytherura umbonata*, Williamson, Mem. Manch. Lit. and Phil. Soc., vol. viii., 1847, p. 79, pl. iv., fig. 78. *Cytheropteron umbonatum*, Will. sp. Jones, Mon. Cret. Entom. (Pal. Soc.), 1890, p. 40, pl. i., figs. 21-26.

2. *Cythere acanthoptera*, Marsson, Mittheil, naturw. Ver. Neu-Vorpommern und Rügen, 1880, p. 45, pl. iii., figs. 14a-c. *Cytheropteron umbonatum*, Will. sp. var. *acanthoptera*, Marsson, var., Jones, Mon. Cret. Entom. (Pal. Soc.), 1890, p. 41, pl. i., figs. 11-13; pl. iv., figs. 22-29.

surface. The Australian specimen is short-spined and punctate, and differs from *C. umbonatum* in the greater length of the shell and the deeper median sulcus.

Occurrence.—Bore 8, 210-219 feet (Kalimnan or Janjukian).

CYTHEROPTERON PRAEANTARCTICUM, sp. nov. (Plate IX., Figs. 39*a*, *b*).

Description.—Valve, seen from the side, oblong, tapering to the anterior, which is rounded, produced posteriorly. Margins surrounded by a distinct rounded flange; dorsal strongly convex and slightly sinuous, ventral nearly straight. Surface compressed towards the dorsal margin, rising rapidly from the antero-dorsal to the ventral side to form a prominent ala with a moderately sharp point, but not hooked. The caudal extremity is sharp and superficially rounded. Edge view of carapace, trapezoidal. Surface of valve on the alar slope depressed in the median area, and vellicate, marked by numerous fine punctations.

Dimensions.—Length, .638 mm.; height, to point of ala, .4 mm.; thickness of carapace, .73 mm.

Affinities.—The relationship of the present species clearly lies with the Antarctic species, *C. antarcticum*, recently found by me in material from a raised beach (Pleistocene) S.E. of Mt. Larsen (Shackleton Expedition, 1908). That species differs, however, in the more attenuated carapace, and the sharply pointed but less expanded alar process. Another species approaching the above *C. praeantarcticum* is *Cytheropteron hamatum*, G. O. Sars, which differs essentially in the more depressed alae with their hooked terminals. The latter is a North Atlantic and Arctic species, in Pleistocene and recent deposits.

Occurrence.—Bore 9, 256-263 feet (Kalimnan).

CYTHEROPTERON RETICOSUM, sp. nov. (Plate IX., Figs. 40*a*, *b*)

Description.—Carapace subquadrate, compressed. Seen from the side, of nearly equal width from end to end; anterior extremity broadly rounded, posterior caudate; dorsal margin widely convex, ventral nearly straight; a depressed flange runs round almost the

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1. *Cytheropteron vespertilio*, G. S. Brady, non Reuss, 1868, Ann. and Mag. Nat. Hist., ser. 4, vol. ii., p. 33, pl. v., figs. 6, 7. *Cytheropteron hamatum*, G. O. Sars, 1869, Nye Dybvandscrustaceer fra Lofoten. Vidensk Forhand., p. 172.

entire valve margin. Alar beak moderately salient, gradually rising from the antero-dorsal angle towards the postero-ventral, and terminating in a sharp marginal angle; surface of ala depressed under the carinal edge, near the posterior extremity of the shell; caudate portion of the carapace much compressed. Edge view suboval, compressed at the extremities, and broader towards the posterior third. Shell surface covered with a fine network of irregularly polygonal areolae.

Dimensions.—Length, .58 mm.; height, .31 mm.; thickness of carapace, .16 mm.

Affinities.—So far as I am aware the nearest living species is *C. wellingtoniense*, G. S. Brady,[1] which was dredged in Wellington Harbour, New Zealand. *C. reticosum* differs in having more quadrate valves, more prolonged alae and a reticulated ornament. In general form it is like a much compressed variety of *Cytheropteron batesfordiense.*

Occurrence.—Bore 10, 195-225 feet (Kalimnan).

CYTHEROPTERON ROSTRATUM, sp. nov. (Plate IX., Figs. 41*a*, *b*).

Description.—Shell compressed, ovate; in side view arcuately oval, highest in the middle; anterior extremity compressed, narrowly rounded, the posterior extremity subacute, excavated ventrally; dorsal margin strongly arched, curving steeeply to the extremities. Ventral margin concave in the lower middle, and convex towards the anterior end. Edge view compressed ovate, acute at anterior, blunt at posterior end. Surface of valves finely and striately punctate, the ornament being concentric with the margins. The surface markings are more distinctly seen when the shell surface is moistened.

Dimensions.—Length, .423 mm.; height, .21 mm.; thickness of carapace, .21 mm.

Affinities.—The nearest allied species to the above is *Cythere scaphoides*, G. S. Brady,[2] from Kerguelen Island, in 20-50 fathoms. They differ, however, in the outline, for the living species is oblong and not arcuate. The surface ornament in both forms is similar.

Occurrence.—Bore 11, 267-270 feet (Janjukian).

1. Rep. Chall. Zool., vol. i., pt. iii., 1880, p. 136, pl. xxxiv., figs. 4*a*-*d*.
2. Tom. supra cit., p. 136, pl. xxxiii., figs. 1*a*-*d*.

Fam. CYTHERELLIDAE.

Genus CYTHERELLA, Jones.

CYTHERELLA AURICULUS, sp. nov. (Plate IX., Figs. 42*a*, *b* ; 43).

Description.—Carapace oblong, compressed. Seen from the side, valves subquadrate, with a marginal raised rim and depressed central area relieved in the median line by a raised longitudinal and crescentic bar. In the young example figured the central raised band starts from the dorsal margin, and continues to curve down and round, all but enclosing a central suboval space; dorsal margin nearly straight, with a median concavity, ventral broadly concave; both extremities widely rounded. Edge view narrow oblong, relieved by the marginal and median prominences. The general, depressed surface of the valve is roughly granulate, the marginal and central bars smooth.

Dimensions.—Length of larger type specimen, .71 mm.; width, .41 mm.; thickness of carapace, .3 mm.

Length of smaller type specimen, .5 mm.; width, .27 mm.

Affinities.—There is one living species, *Cytherella latimarginata*, G. S. Brady,[1] which resembles the above in having an encircling fillet around the margin, but the centre of the valve is occupied by a long, rounded protuberance, instead of a narrow curved bar as in *C. auriculus*, the latter more nearly resembling the contour of an ear, hence the name.

The closest affinity lies, however, with some Cretaceous forms well known from the English and European Chalk, the central type of which is *Cytherella williamsoniana*, Jones.[2] This species has the central bar broken to some extent, whilst the restricted character of the central ornament, especially in our smaller figured type, is perhaps more nearly approached in *Cytherella chapmani*, Jones,[3] from the Gault of Godstone, Surrey, England.

It is extremely curious to find this species and the previously mentioned *Cytheropteron postumbonatum* of the Australian Miocene so closely approaching their Cretaceous analogues.

Occurrence.—Bore 11, 219-260 feet (Kalimnan).

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1. Rep. Chall. Zool., vol. i., pt. iii., 1880, p. 178, pl. xxxvi., figs. 7*a*-*d*.
2. Mon. Cret. Entom. (Pal. Soc.), 1849, p. 31, pl. vii., figs. 26*a*-*h*. Id., ibid., 1890, p. 48, pl. iii., figs. 55-62.
3. Mon. Cret. Entom. (Pal. Soc.), 1890, p. 49, pl. iii., fig. 70.

CYTHERELLA LATA, G. S. Brady. (Plate IX., Figs. 44*a*, *b*).

Cytherella lata, G. S. Brady, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 173, pl. xliv., figs. 5*a-e*.

Observations.—This species is found in the living condition in as widely separated areas as the West Indies and the Japanese Sea. At Torres Strait it was found in 155 fathoms.

The fossil example here depicted differs in no essential details from the valves of the living form.

Occurrence.—Bore 5, 163-175 feet (Kalimnan or Janjukian).

CYTHERELLA POLITA, G. S. Brady. (Plate IX., Figs. 45*a*, *b*).

Cytherella polita, G. S. Brady, 1868, Les Fonds de la Mer, p. 161, pl. xix., figs. 5-7. Idem, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 172, pl. xliii., figs., 5*a-c*; pl. xliv., figs. 1*a-g*.

Observations.—This species has been recorded in the living condition from the West Indies; Wellington Harbour, New Zealand, in the tow-net; and from the mouth of Rio de la Plata, 13 fathoms.

Cytherella polita is one of the best distributed of the cytherellids in the Mallee washings. The fossil examples agree in practically all points with the recent, with the exception that the former tend to exhibit a broader anterior border.

Occurrence.—Bore 5, 153-175 feet (Kalimnan or Janjukian). Bore 8, 210-219 feet (Kalimnan or Janjukian). Bore 9, 315-325 feet (Kalimnan or Janjukian). Bore 10, 160-186 feet; 195-225 feet (Kalimnan). Bore 11, 457-458 feet; 546-548 feet (Janjukian).

CYTHERELLA PULCHRA, G. S. Brady. (Plate IX., Figs. 46*a*, *b*).

Cytherella pulchra, G. S. Brady, 1866, Trans. Zool. Soc., Lond., vol. v., p. 361, pl. lvii., figs. 1*a-d*. Idem, 1880, Rep. Chall. Zool., vol. i., pt. iii., p. 174, pl. xliv., figs. 3*a*, *b*.

Observations.—The living examples were found at Port Jackson at 2-10 fathoms; and off Ascension Island, 42 fathoms. As in many other instances in the Mallee fauna, this species has survived in Australian waters from Miocene times. The fossil examples are identical in all points with the type of the living form. *C. pulchra*

may be readily distinguished from *C. polita*, not only in the narrower extremities, but also in the angularly tumid outline of the carapace in edge view. It is extremely abundant in the washings from the Mallee bores, and occurs from the Miocene upwards.

Occurrence.—Bore 2, 198-200 feet (Kalimnan). Bore 3, 260 feet, circ. (Janjukian). Bore 4, 163-170 feet (Kalimnan). Bore 9, 256-263 feet; 315-325 feet (Kalimnan or Janjukian). Bore 10, 230-254 feet (Kalimnan). Bore 11, 175-197 feet; 197-199 feet; 219-260 feet (Kalimnan). 349-353 feet; 540-542 feet; 554-556 feet; 558-560 feet (Janjukian).

CYTHERELLA PUNCTATA, G. S. Brady. (Plate IX., Fig. 47).

Cytherella punctata, G. S. Brady, 1866, Trans. Zool. Soc., Lond., vol., v., p. 362, pl. lvii., figs., 2*a*, *b*. Idem, 1880, Rep. Chall. Zool., vol., i., pt. iii., p. 174, pl. xxxvi., figs. 6*a*, *b*.; pl. xliv., figs., 4*a-g*. Egger, 1901, Abhandl. d. k. bayer. Akad. Wiss., vol. xxi., abth. ii., p. 469, pl. iv., figs. 34, 35.

Observations.—As a recent species this is one of the deeper water forms of the genus *Cytherella*. It has been noted from Tristan d'Acunha; Port Jackson; from Challenger Sta. 167 in the Southern Ocean between Sydney and New Zealand; off the Ki Islands; and in the Straits of Magellan.

Egger records the above species from the west coast of Australia at 357 metres.

Occurrence.—Bore 6, 114-150 feet (Kalimnan). Bore 9, 256-263 feet (Kalimnan or Janjukian). Bore 11, 267-270 feet (Janjukian).

CYTHERELLA SUBTRUNCATA, sp. nov. (Plate IX., Figs. 48*a*, *b*).

Description.—Carapace, from the side, compressed oblong or subrectangular, with broadly rounded extremities; dorsal margin nearly straight, slightly concave in the middle, ventral broadly concave, antero- and postero-ventral angles rather more produced than the dorsal; encircling border or flange fairly conspicuous on the ventral edge. Median surface depressed. Seen from below, compressed, elongate, pyriform, the contour depressed in the middle, anterior extremity compressed and rounded, the posterior inflated and much thicker. Surface smooth.

Dimensions.—Length, .73 mm.; width, .365 mm.; thickness of carapace, .29 mm.

Affinities.—The above species differs from Dr. Brady's *C. truncata*[1] in having a depression in the median face of each valve, and in the swollen and truncated posterior extremity in edge view.

The allied *C. truncata* has been recorded from Torres Strait. The present fossil species is from a Kalimnan (Lower Pliocene) horizon in both cases.

Occurrence.—Bore 10, 225-230 feet (Kalimnan). Bore 11, 175-197 feet (Kalimnan).

Super-Order CIRRIPEDIA.

Fam. LEPADIDAE.

Genus SCALPELLUM, Leach.

SCALPELLUM SUBQUADRATUM, sp. nov. (Plate X., Figs. 49*a-d*; 50 and 51*a, b*).

Description.—Carina (holotype).—Elongate, strongly bowed inwardly, with roof flat, gradually and evenly widening from apex to base, and very slightly convex towards the basal margin; surface smooth except for faint growth-lines. Sides generally flat, thus giving a square-sided appearance to the valve, and also showing indications of a median groove. Basal margin broadly rounded. Inner surface of valve deeply concave. Inner edge of carina crenulate near the apex, and cut through by short channels near the base.

Another specimen (paratype), and probably the rostral latus, is narrow, of slightly thinner build, and showing strongly arched growth-lines along the length of the valve; inner surface concave and smooth.

Scutum (paratype), elongate triangular; occludent margin perfectly straight, basal, angularly rounded; tergal margin slightly concave, with a nodulose edge. A longitudinal ridge runs from the apex to the base, and close to the occludent margin. Superficial growth-lines and shaded colour-patches very distinct. Inner surface shows the pit for the adductor scutorum, above which is a deep fold running to the apex, and marked by some linear and sinuous lines of growth.

Dimensions.—Carina (holotype), extreme apex wanting. Length, 20 mm.; width at the base, 4.5 mm.; thickness of carina near apical end, 2.25 mm.

1. Les Fonds de la Mer, 1868, p. 154, pl. xix., figs. 3, 4. Rep. Chall. Zool., vol. i., pt. iii., 1880, p. 174, pl. xxxvi., figs. 8a-d.

Rostral latus, extreme apex wanting. Length, 8 mm.; width at base, 2.25 mm.; thickness of carina at apical end, 1 mm.

Scutum. Length, minus apex, 7.75 mm.; greatest width, 9 mm.

Affinities.—The above species shows a remarkable resemblance to *Scalpellum quadratum*, Dixon sp.,[1] a form which occurs in the Londinian (Eocene, London clay) of Bognor, in Sussex and Hampstead, near London, England. As in *S. subquadratum*, the lines of growth start from the apex as noted by Darwin for that species. From the living *Scalpellum rutilum*, Darwin,[2] this carina differs in the flat, ungrooved roof, and strongly arched growth-lines.

A species of *Scalpellum* (*S. juliense*, Ortmann[3]), has been described from the Miocene of Patagonia, in which the outer surface of the carina is convexly rounded, and not flattened as in our species.

Observations.—The largest specimen (holotype) is incomplete, but probably wanting only 5 or 6 mm. The specimen was originally found in two parts, washed from a large quantity of clay, and it was only when examining the material in detail that the two parts were found to fit together.

Occurrence.—Bore 4, 163-170 feet, holotype and paratype (Carina and Scutum),—(Kalimnan or Janjukian). Bore 10, 310-320 feet, paratype (rostral latus), (Kalimnan or Janjukian).

Fam. BALANIDAE.

Genus BALANUS, Lister.

BALANUS PSITTACUS, Molina sp. (Plate X., Figs. 52*a*, *b*).

Lepas psittacus, Molina, 1788, Hist. Nat., Chile, vol. i., p. 223.

Balanus psittacus, Molina sp. Darwin, 1854, Mon. Cirripedia (Ray Soc.), vol. ii., p. 206, pl. ii., figs. 3*a-d*.

Balanus cf. *psittacus*, Molina sp., Ortmann, 1902, Rep. Princeton Univ. Exped., vol. iv., pt. ii., p. 249, pl. xxxviii., fig. 2.

Observations.—The identification of the Mallee specimens of the above, consisting as they do of only separated compartments, would have been practically impossible but for the other and more complete examples from the Kalimnan of Beaumaris in the

1. *Xiphidium quadratum*, Dixon, in Sowerby's Mineral Conch, vol. vii., 1846., pl. dcxlviii. Dixon, Geol. of Sussex, 1850, pl. xiv., figs. 3, 4. *Scalpellum quadratum*, Dixon sp. Darwin, Mon. Foss. Lepadidae (Mon. Pal. Soc.), 1851, p. 22, pl. i. fig. 3.

2. Mon. Cirripedia (Ray. Soc.), 1851, p. 253, pl. vi., fig. 2.

3. Rep. Princeton Univ. Exped., Patagonia, 1896-9, vol. iv., pt. ii., 1902, p. 247, pl. xxxvii. figs. 9*a-c*.

National Museum (W. Kershaw coll.), and from the same horizon at Muddy Creek, near Hamilton, in the Dennant collection. The example from Beaumaris is identifiable with the specimen referred to, *B.* cf. *psittacus*, Molina sp., which has been found fossil in the Tertiary beds of Patagonia. *B. psittacus* is still found living, according to Darwin, along the coast of Chili, and very abundant at a few fathoms depth. Darwin remarks (loc. cit.) that this species is distinguished externally from *B. tintinnabulum*, another large and well-known form, by its hexagonal rather than its trigonal orifice, and, moreover, is not tinted so darkly as the latter species. It is the largest species of the genus, sometimes attaining a length, in the living examples, of nine inches.

Isolated compartments of the above species were found in the Mallee bore at one depth only. The Mallee specimens retain much of their original colour, although coming from the deepest part of bore 9, the sample of which contained a mixed Janjukian and Kalimnan fauna, and may be as old as the Miocene. One of the Mallee fossils is of a pale purplish tint, with about 7 primary and 7 secondary fine, longitudinal ribs of a dark purple. These ribs are noted by Darwin (loc. cit., p. 207), and also depicted by Ortmann (loc. cit., fig. 2). A fragment of the base of the parietes in one of the Mallee specimens indicates the deep cup-shaped habit of attachment in this species. In regard to the parietal tubes, as Darwin notes, they are unusually large in proportion to the size of the shell, and run up to the summit without any transverse septa. "The radii," to again quote Darwin, "are generally very highly developed, so that their summits are even wider than the bases of the parietes; but on the other hand, in some few large specimens, the radii are either very narrow or absolutely linear." In the figured specimen from the Mallee it will be noticed that the radii are similarly well-developed. The septa of the radii in the Mallee examples, as in the living *B. psittacus*, are strongly denticulated, as shown here (fig. 52*b*).

Occurrence.—Bore 4, 163-170 feet (Kalimnan or Janjukian). Bore 9, 315-325 feet (Kalimnan or Janjukian).

BALANUS VARIANS, Sowerby. (Plate X., Figs. 53, 54).

Balanus varians, G. B. Sowerby, 1846, in Darwin's Geol. Observations on South America, pl. ii., figs. 4-6. Darwin, 1854, Mon. Cirripedia (Ray Soc.), vol. ii., p.

298, pl. viii., fig. 9. Ortmann, 1902, Rep. Princeton Univ. Exped., Patagonia, vol. iv., pt. ii., p. 250, pl. xxxviii., figs. 3*a-e*.

Observations.—By comparing the Mallee specimens with many other complete examples from Victoria, so far as regards the parietes and in one instance where the opercular plates have been preserved, one is enabled to draw some satisfactory conclusions as to the identity of the very abundant remains of barnacles in the borings. The compartments are all separate, excepting one instance, which is here figured. Like the preceding species, this form also occurs in the Patagonian Tertiaries at San Julian, and the scutum therein found (loc. cit., fig. 3*d*) is comparable with a specimen lately worked out of a fossil barnacle from Beaumaris, which I refer to the above species.

At first sight one would be inclined to place the fossil forms in the genus *Chthamalus*, as was done in the Dennant collection, but bearing in mind the distinctive features of the two genera, which have reversed characters as to disposition of alae and radii, the rostrum of *Balanus* possessing radii and not alae as in *Chthamalus*, as Darwin pointed out, the separation is at once easily made.

All the Mallee examples have the walls of the parietes strongly folded, but some specimens from Ascot, western Victoria, in the Dennant collection, identified as *Chthamalus stellatus*, have nearly smooth parietes.

The separated compartments of this species of *Balanus* are common in many of the bores, and seem to make their appearance at the top of the Janjukian, where, in Bore 9 at 315-325 feet, they are exceedingly common.

Occurrence.—Bore 6, 114-150 feet (Kalimnan); 158-161 feet (Kalimnan or Janjukian). Bore 8, 165-180 feet; 180-199 feet; 204-210 feet (Kalimnan or Janjukian). Bore 9, 254-256 feet (Kalimnan); 256-263 feet; 315-325 feet (Kalimnan or Janjukian). Bore 10, 254-296 feet; 310-320 feet (Janjukian). Bore 11, 197-199 feet; 199-209 feet (Kalimnan).

Class PISCES.

Fam. CESTRACIONTIDAE.

Genus CESTRACION, Cuvier.

CESTRACION CAINOZOICUS, Chapman and Pritchard. (Plate X., Fig. 55).

Cestracion cainozoicus, Chapman and Pritchard, 1904, Proc. Roy. Soc., Vict., vol. xvii. (N.S.), pt. i., p. 270, pl. xi., figs. 5-8; pl. xii., fig. 2.

An antero-lateral crushing tooth occurs in one of the bores at an horizon where fish remains are abundant, and which may be relegated to the top of the Janjukian. There is little doubt that it is related to the specific form which has been previously recorded from various localities in Victoria at or near the base of the Kalimnan. The formerly recorded occurrences were nearly all represented by the strong, broad lateral crushing teeth. The genus dates from Upper Jurassic times (*C. falcifer*, in the Solenhofen stone of Bavaria).

Occurrence.—Bore 8, 210-219 feet (Kalimnan or Janjukian).

Fam. TRYGONIIDAE.

Genus TRYGON, Adanson.

TRYGON CF. RUGOSUS, Probst sp. (Plate X., Figs. 56*a-d*).

Raia rugosus, Probst, (?) 1874, Beitrage zur Kenntniss der fossilien Fische ous der Molasse von Baltringen,—Wurrtemberg Naturw. Jahresheft 1874-82 (not seen). Zittel-Barrois, 1893, Traite de Paleontologie, pt. i., vol. iii., pp. 102, 103, fig. 120*a-c*. *Trygon rugosus*, Probst sp. Eastman-Zittel, 1902, Text-book of Palaeontology, p. 42, fig. 83.

Observations.—A single specimen of a well-preserved tooth with bifurcated root was found in a sample of the Mallee bores containing an admixture of Kalimnan and Janjukian shells, but with a predominance of the latter fauna. Both in width and height the tooth measures 4.25 mm. In the Miocene marls of Baltringen, Wurtemberg, Probst found a similar pavement tooth, which he referred to *Raia*, but which has since been placed in the genus Trygon. Our specimen is in close agreement as regards both shape and structure, so that it seems advisable for the present to refer it tentatively to Probst's species, which came from a similar, or nearly similar, formation.

In respect to the generic position of the tooth, the marginal or border teeth of the living Thornbacks (*Raia*), which I have been able to examine in the National Museum through the kind offices of Mr. J. A. Kershaw, show a bicuspid root, but differing from the present specimen in having it more expansive or less hook-like than in the Mallee fossil.

Occurrence.—Bore 5, 163-175 feet (probably Janjukian).

Fam. MYLIOBATIDAE.

Genus MYLIOBATIS, Cuvier.

MYLIOBATIS MOORABBINENSIS, Chapman and Pritchard. (Plate X., Fig. 57).

Myliobatis moorabbinensis, Chapman and Pritchard, 1907, Proc. Roy. Soc., Vict., vol. xx. (N.S.), pt. i., p. 60, pl. v., figs. 1-3.

This species is represented in the Mallee bores in three samples by median palatal teeth. They agree in all particulars with the type examples from Beaumaris, with the exception of the figured specimen from the Mallee, which has a slightly larger number of denticles in a given length on the articulating surface. In its slender form and small size, whilst resembling the above species, it seems quite distinct from the living *Myliobatis australis*, Macleay. The type specimens came from a Kalimnan (Lower Pliocene) horizon.

Occurrence.—Bore 4, 163-170 feet (Kalimnan or Janjukian). Bore 9, 315-325 feet (Kalimnan or Janjukian). Bore 10, 225-230 feet (Kalimnan)—(figd. specimen).

Fam. SPARIDAE.

Genus CHRYSOPHRYS, Cuvier.

(?) CHRYSOPHRYS sp. (Plate X., Figs. 58, 59).

Observations.—Numerous small, rounded, grinding teeth occur in the clay washings from one or two of the Mallee bores. They are exactly comparable with those found in the Sea-Breams or *Chrysophrys*, living at the present time in Australian seas. When the basal surface is examined the structure is seen to be the same as in the living genus mentioned. Their occurrence as isolated teeth show them to be easily detachable from their cartilaginous setting, and therefore different from the closely paved pharyngeal dentition in *Labrodon.* Towards the base the tooth is frequently surrounded by a distinct cincture at its junction with the socket. The apex of the tooth is often worn, and shows a concentric structure.

Occurrence.—Bore 3, 201-220 feet (Kalimnan or Janjukian); 226 feet (Janjukian). Bore 8, 210-219 feet (Kalimnan or Janjukian).

A Complete List of Fossils found in the Mallee Borings; with their probable Geological Horizons.

Janjukian (J) = Miocene. Kalimnan (K) = Lower Pliocene.
Werrikooian (W) = Upper Pliocene. K or J = mixed sample.

Name.	Geological horizons.
Plantae.	
Boring Fungus, indet.	K. ?J.
Lithothamnion ramosissimum, Reuss sp.	J.
Lithothamnion, aff. lichenoides, Ellis and Solander	J.
Lithophyllum sp.	J.
Animalia.	
Foraminifera—	
Biloculina elongata, d'Orbigny	K.
Biloculina irregularis, d'Orbigny	K. ?J.
Miliolina oblonga, Montagu sp.	K. (common). J. (rarely).
Miliolina circularis, Bornemann sp.	K. ?J.
Miliolina trigonula, Lamarck sp.	K. ?J.
Miliolina seminulum, Linné sp.	W. K. J.
Miliolina vulgaris, d'Orb. sp.	K. J.
Miliolina cuvieriana, d'Orb. sp.	J.
Miliolina ferussacii, d'Orb. sp.	K.
Miliolina bicornis, Walter and Jacob sp.	K. or J.
Miliolina schreiberiana, d'Orb. sp.	K.
Miliolina agglutinans, d'Orb. sp.	K. or J.
Miliolina (Massilina) secans, d'Orb. sp.	K.
Trillina howchini, Schlumberger	?K. J.
Sigmoilina schlumbergeri, A. Silvestri	J.
Planispirina sphaera, d'Orb. sp.	J.
Planispirina exigua, Brady	K. or J.
Hauerina intermedia, Howchin	K. or J.
Orbitolites complanata, Lam.	K. J.
Haplophragmium emaciatum, Brady	K. or J.
Haplophragmium canariense, d'Orb. sp.	K. or J.
Haplophragmium sphaeroidiniforme, Brady	J.
Ammodiscus ovalis, Chapman	W.
Textularia gibbosa, Brady	K. or J.
Spiroplecta sagittula, Defrance sp.	J.
Spiroplecta gramen, d'Orb. sp.	J.
Gaudryina pupoides, d'Orb.	K. or J.
Gaudryina rugosa, d'Orb.	?K. J.
Verneuilina spinulosa, Reuss	J.
Bulimina elegans, d'Orb.	J.
Bulimina elegantissima, d'Orb.	K. J.
Bulimina contraria, Reuss sp.	J.
Virgulina schreibersiana, Czjzek	J.
Bolivina punctata, d'Orb.	?K. J.

Name.	Geological horizons.
Bolivina textilarioides, Reuss - - -	J.
Bolivina nobilis, Hantken - - - -	J.
Bolivina limbata, Brady - - - -	J.
Bolivina robusta, Brady - - - -	K.
Cassidulina subglobosa, Brady - - -	?K. J.
Cassidulina oblonga, Reuss - - - -	J.
Lagena gracilis, Williamson - - -	K. or J.
Lagena squamosa, Montagu sp. - - -	J.
Lagena schlichti, A. Silv. - - - -	K. J.
Lagena marginata, Walker and Boys - -	K. or J.
Lagena orbignyana, Seguenza - - -	K. or J.
Nodosaria (Glandulina) laevigata, d'Orb. - -	K. or J.
Nodosaria scalaris, Batsch, sp. - - -	J.
Nodosaria raphanus, Linné sp. - -	K. ?J.
Nodosaria badenensis, d'Orb. - - -	K. or J.
Nodosaria affinis, d'Orb. - - - -	K. or J.
Nodosaria (Dentalina) pauperata, d'Orb. sp. -	J.
Nodosaria (D.) consobrina, d'Orb. - - -	J.
Nodosaria (D.) soluta, Reuss - - -	J.
Nodosaria (D.) multilineata, Born. sp. - -	J.
Nodosaria (D.) obliqua, Linné sp. - - -	?K. J.
Frondicularia complanata, Defr. - - -	W. K.
Frondicularia inaequalis, Costa - - -	J.
Frondicularia lorifera, Chapman - - -	?K. J.
Marginulina glabra, d'Orb. - - - -	?K. J.
Marginulina costata, Batsch sp. - - -	J.
Vaginulina legumen, Linné sp. - - -	J.
Cristellaria tricarinella, Reuss - - -	J.
Cristellaria aculeata, d'Orb. - - - -	J.
Cristellaria articulata, Reuss (keeled var.) -	K. or J.
Cristellaria rotulata, Lam. sp. - - -	?K. J.
Cristellaria cultrata, Montfort sp. - - -	?K. J.
Polymorphina lactea, Walker and Jacob sp. -	W. K. J.
Polymorphina gibba, d'Orb. - - -	J.
Polymorphina compressa, d'Orb. - - -	W. K. ?J.
Polymorphina elegantissima, Parker and Jones -	K. J.
Polymorphina dispar, Stache - - -	J.
Polymorphina communis, d'Orb. - - -	K. J.
Polymorphina problema, d'Orb. - - -	K. J.
Polymorphina oblonga, d'Orb. - - -	K. J.
Polymorphina regina, Brady, Parker and Jones -	K. J.
Polymorphina sororia, Reuss - - -	K. or J.
Polymorphina rotundata, Born. sp. - -	?K. J.
Uvigerina angulosa, Williamson - - -	J.
Uvigerina tenuistriata, Reuss - - -	K.
Sagraina striata, Schlumberger - - -	K.
Sagraina raphanus, Parker and Jones - -	J.
Globigerina bulloides, d'Orb. - - -	J.
Globigerina triloba, Reuss - - - -	J.
Globigerina conglobata, Brady - - -	J.
Pullenia quinqueloba, Reuss - - -	W.

Name.	Geological horizons.
Sphaeroidina bulloides, d'Orb.	J.
Patellina corrugata, Will.	K. J.
Discorbina araucana, d'Orb. sp.	W.
Discorbina bertheloti, d'Orb. sp.	?K. J.
Discorbina parisiensis, d'Orb. sp.	?K. J.
Discorbina dimidiata, Parker and Jones	J.
Discorbina globularis, d'Orb. sp.	?J.
Discorbina turbo, d'Orb. sp.	K. J.
Discorbina pileolus, d'Orb. sp.	J.
Discorbina obtusa, d'Orb. sp.	J.
Discorbina biconcava, Parker and Jones	J.
Planorbulina larvata, Parker and Jones	?K. J.
Truncatulina lobatula, Walker and Jacob sp.	K. J.
Truncatulina variabilis, d'Orb.	J.
Truncatulina refulgens, Montfort sp.	W. K. J.
Truncatulina wuellerstorfi, Schwager sp.	K.
Truncatulina ungeriana, d'Orb. sp.	W. K. J.
Truncatulina akneriana, d'Orb. sp.	J.
Truncatulina, reticulata, Czjzek sp.	J.
Truncatulina tenera, Brady	J.
Truncatulina haidingeri, d'Orb. sp.	K. J.
Anomalina ammonoides, Reuss sp.	K. J.
Anomalina polymorpha, Costa	?K. J.
Carpenteria proteiformis, Goës	J.
Pulvinulina elegans, d'Orb. sp.	K. J.
Pulvinulina elegans, var. partschiana, d'Orb. var.	J.
Pulvinulina repanda, Fichtel and Moll, sp.	W. K. J.
Pulvinulina repanda, var. concamerata, Mont. var.	J.
Pulvinulina calabra, Costa sp.	K. or J.
Pulvinulina auricula, Fichtel and Moll. sp.	K.
Pulvinulina karsteni, Reuss	J.
Pulvinulina truncatulinoides, d'Orb. sp.	J.
Pulvinulina schreibersii, d'Orb. sp.	J.
Rotalia beccarii, L. sp.	W. K. J.
Rotalia papillosa, Brady	K. or J.
Rotalia papillosa, var. compressiuscula, Brady	K. J.
Rotalia clathrata, Brady	K. J.
Rotalia calcar, d'Orb. sp.	J.
Rotalia orbicularis, d'Orb. sp.	?K. J.
Rotalia soldanii, d'Orb.	?K. J.
Rotalia venusta, Brady	J.
Gypsina howchini, Chapman	J.
Gypsina vesicularis, Parker and Jones	J.
Gypsina globulus, Reuss sp.	?K. J.
Nonionina depressula, Walker and Jacob sp.	W. J.
Nonionina umbilicatula, Mont. sp.	J.
Nonionina boueana, d'Orb.	K.
Nonionina scapha, F. and M. sp.	K. or J.
Polystomella striatopunctata, Fichtel and Moll. sp.	W. K.

Name.	Geological horizons.
Polystomella striatopunctata, var. evoluta, Chapman	K. ?J.
Polystomella macella, Fichtel and Moll. sp.	K. J.
Polystomella crispa, L. sp.	W. K. J.
Polystomella subnodosa, Münster sp.	K. or J.
Polystomella imperatrix, Brady	J.
Polystomella verriculata, Brady	?K. J.
Polystomella craticulata, Fichtel and Moll. sp.	K. J.
Amphistegina lessonii, d'Orb.	?K. J.
Operculina complanata, Defr.	?K. J.
Operculina complanata, var. granulosa, Leymerie	K. J.
Operculina venosa, Fichtel and Moll. sp.	J.
Spongiae—	
Calcisponges, triradiate spicules of,	K. (rare). J.
Anthozoa—	
Holcotrochus crenulatus, Denant	K.
Placotrochus elongatus, Duncan	?K. J.
Placotrochus deltoideus, Duncan	?K. J.
Sphenotrochus emarciatus, Duncan	?K. J.
Deltocyathus fontinalis, Dennant	?K. J.
Bathyactis lens, Duncan sp.	?K. J.
Bathyactis beaumariensis, Dennant	K. ?J.
Notophyllia variolaris, Dennant	K. J.
Graphularia senescens, Tate sp.	K. or J.
Mopsea tenisoni, Chapman	?K. J. (common).
Mopsea hamiltoni, Thomson	?K. J.
Isis compressa, Duncan	J.
Echinoderma—	
Antedon protomacronema, Chapman	J.
Pentagonaster sp.	K. J. (common).
Cidaris sp.	J.
Goniocidaris sp.	J.
Paradoxechinus novus, Laube	J.
Psammechinus woodsi, Laube sp.	J.
Echinocyamus (Scutellina) patella, Tate sp.	?K. J. (common).
Fibularia gregata, Tate	?K. J. (common).
Clypeaster gippslandicus, McCoy	K. ?J.
Arachnoides (Monostychia) australis, Laube sp.	?K. J.
Echinoneus dennanti, Hall	J.
Linthia sp.	K. or J.
cf. Eupatagus sp.	J.
Lovenia forbesi, T. Woods sp.	?K. J.
Annelida—	
Serpula ouyenensis, Chapman	?K. J.
Ditrupa cornea, L. sp., var. wormbetiensis, McCoy	K. J. (common).
Ditrupa cornea, L. sp., var. constricta, Chapm.	?K. J.
Spirorbis heliciformis, Eichwald	K. J.
Polyzoa—	
Cyclostomata—	
Idmonea hochstetteri, Stoliczka sp.	K. or J.
Idmonea lata, Macgillivray	K. or J.

Name.	Geological horizons.
Hornera diffusa, Macgillivray	K. or J.
Hornera frondiculata, Lamaroux	K. or J.
Diastopora patina, Lamaroux	J.
Entalophora nr. sparsa, Maplestone	K. or J.
Entalophora verticillata, Goldfuss sp.	J.
Lichenopora australis, Macgill.	K. or J.
Lichenopora porosa, Macgill.	?K. J. (common).
Lichenopora radiata, Audrouin sp.	J.
Lichenopora wilsoni, Macgill.	J.
Heteropora pisiformis, Macgill.	K. or J.
Cheilostomata—	
Catenicella sp.	K.
Claviporella sp.	K. or J.
Caberea grandis, Hincks	K. or J.
Cellaria acutimarginata, Macgill. sp.	J.
Cellaria angustiloba, Busk sp.	J.
Cellaria australis, Macgill.	K. J.
Cellaria contigua, Macgill.	?K. J. (common).
Cellaria rigida, Macgill.	?K. J. (common).
Cellaria rigida, var. perampla, Waters	J.
Cellaria rigida, var. venusta, Macgill.	J.
Membranipora cf. fossa, Macgill.	J.
Lunulites canaliculata, Macgill.	K. or J.
Lunulites (?) parvicella, T. Woods sp.	K.
Selenaria cf. concinna, T. Woods	K. or J.
Selenaria cupola, T. Woods sp.	K. J.
Selenaria marginata, T. Woods	K. J.
Selenaria marginata, var. lucens, Macgill.	K. ?J.
Selenaria marginata, var. pulchella, Macgill.	K. or J.
Selenaria marginata, var. spiralis, Chapman	K. ?J.
Steganoporella magnilabris, Busk sp.	J.
Steganoporella patula, Waters sp.	J.
Macropora clarkei, T. Woods sp.	J.
Microporella magna, T. Woods sp.	J.
Tessarodoma elevata, Waters sp.	J.
Tessarodoma magnirostris, Macgill.	J.
Adeona sp.	J.
Lepralia burlingtoniensis, Waters	J.
Lepralia corrugata, Macgill.	J.
Lepralia crassatina, Waters sp.	J.
Lepralia elongata, Macgill.	?K. J.
Lepralia gippslandii, Waters	K. or J.
Lepralia (?) graysoni, Maplestone	J.
Schizoporella (?) convexa, Macgill.	K. or J.
Bipora cancellata, Busk sp.	K. or J.
Bipora philippinensis, Busk sp.	?K. J.
Smittia tatei, T. Woods sp.	J.
Porina gracilis, M. Edwards sp.	J.
(?) Lekythopora sp.	J.
Cellepora fossa, Haswell sp.	?K. J. (common).
Cellepora gambierensis, T. Woods	?K. J.

Name.	Geological horizons.
Cellepora tridenticulata, Busk	K. or J.
Cellepora tridenticulata, var, nummularia, Busk	?K. J.
(?) Schismopora costazei, Audr. sp.	J.
Schismopora incus, Macgill.	K. or J.
Retepora producta, Busk	?K. J.
Brachiopoda—	
Terebratulina catinuliformis, Tate	?K. J. (common).
Terebratulina triangularis, Tate	J.
Terebratulina flindersi, Chapm.	J.
Terebratula tateana, T. Woods	J.
Terebratella acutirostra, Chapm.	J.
Terebratella portlandica, Chapm.	K. J.
Magasella compta, Sow. sp.	K. ?J.
Magasella lunata, Tate	?K. J.
Magasella woodsiana, Tate	?K. J.
Magellania garibaldiana, Davidson sp.	J.
Magellania insolita, Tate	J.
Pelecypoda—	
Nucula morundiana, Tate	K.
Nucula obliqua, Lamarck	K. ?J.
Nucula semistriata, Tate	K. ?J.
Leda acinaciformis, Tate	K. ?J.
Leda apiculata, Tate	K.
Leda crassa, Hinds	K.
Leda huttoni, T. Woods	K. or J.
Leda woodsi, Tate	K. ?J.
Cucullaea corioensis, McCoy	K. or J.
Limopsis beaumariensis, Chapm.	K. J. (rare).
Limopsis beaumariensis, var. depressa, Chapm.	K. ?J.
Limopsis insolita, G. Sow. sp.	K. or J.
Arca (Fossularca) dissimilis, Tate sp.	J.
Lissarca rubricata, Tate sp.	K.
Glycimeris cainozoicus, T. Woods sp.	K. or J.
Glycimeris convexus, Tate sp.	K. ?J.
Glycimeris halli, Pritchard	K. ?J.
Glycimeris halli, var. intermedia, Pr.	K. ?J.
Glycimeris halli, var. paucicostata, Pr.	K. ?J.
Glycimeris maccoyi, Johnston sp.	K. ?J.
Perna percrassa, Tate sp.	K. or J.
Pteria (Margaritifera) crassicardia, Tate sp.	K. ?J.
Ostrea hyotidoidea, Tate	K. or J.
Ostrea manubriata, Tate	K. or J.
Gryphaea tarda, Hutton	K. or J.
Trigonia howitti, McCoy	K.
Trigonia lamarcki, Gray	K. or J.
Trigonia margaritacea, Lam., var. acuticostata, McCoy	K. ?J.
Pecten antiaustralis, Tate	K.
Pecten eyrei, Tate	K. or J.
Pecten flindersi, Tate	J.
Pecten foulcheri, T. Woods	J.

Name.	Geological horizons.
Pecten gambierensis, T. Woods	J.
Pecten murrayanus, Tate	K. ?J.
Pecten peroni, Tate	K. or J.
Pecten polymorphoides, Zittel	J.
Pecten praecursor, Chapm.	J.
Pecten sturtianus, Tate	K. or J.
Amussium zitteli, Hutton	K. or J.
Spondylus gaederopoides, McCoy	J.
Dimya dissimilis, Tate	K. or J.
Lima (Limatula) jeffreysiana, Tate	K. J.
Placunanomia ione, Gray	K. or J.
Mytilus deperditus, Tate	K.
Arcoperna scapha, Verco	J.
Crassatellites communis, Tate sp.	K. ?J.
Crassatellites kingicoloides, Pritchard	K.
Cuna concentrica, Hedley	K. ?J.
Cuna polita, Tate sp.	K.
Cuna radiata, Tate sp.	?K. J.
Condylocardia tennuicostae, Chapm. and Gabriel	K. ?J.
Cardita calva, Tate	K.
Cardita compacta, Tate	K. J.
Cardita latissima, Tate	J.
Cardita pecten, Tate	K. ?J.
Cardita solida, Tate	K. ?J.
Cardita spinulosa, Tate	K. ?J.
Rochefortia donaciformis, Angas sp.	J.
Erycina micans, Tate sp.	K.
Montacuta sericea, Tate	K.
Dosinea grayi, Zittel	K.
Venus (Chione) hormophora, Tate sp.	K. or J.
Venus (Ch.) propinqua, T. Woods sp.	K. ?J.
Venus (Ch.) subroborata, Tate sp.	K. ?J.
Meretrix murrayana, Tate sp.	K.
Psammobia aequalis, Tate	K.
Donax kenyoniana, Chapm. and Gabr.	K.
Mactra axiniformis, Tate	K.
Mactra hamiltonensis, Tate	K.
Mactra howchiniana, Tate	K.
Corbula coxi, Pilsbry	K. (common). J. (rare).
Corbula ephamilla, Tate	K. J.
Corbula pyxidata, Tate	K. or J.
Barnea tiara, Tate	K.
Scaphopoda—	
Dentalium aratum, Tate	J.
Dentalium australe, Sharp and Pilsbry	K. or J.
Dentalium latesulcatum, Tate	K. or J.
Dentalium mantelli, Zittel	K. or J.
Cadulus acuminatus, Tate	K.
Polyplacophora—	
Chitons, indet.	K. or J.

Name.	Geological horizons.
Gasteropoda—	
Liopyrga quadricingulata, Tate	K. ?J.
Liopyrga sayceana, Tate	K. or J.
Liotia dennanti, Chapm. and Gabr.	K. or J.
Euchelus tasmanicus, T. Woods	K. or J.
Clanculus aff. aloysii, T. Woods	K. or J.
Teinostoma depressula, Chapm. and Gabr.	K.
Teinostoma pulcherrima, Chapm. and Gabr.	K.
Cyclostrema homalon, Verco	K.
Cyclostrema harriettae, Petterd	K.
Eulima pinguicula, Chapm. and Gabr.	K.
Niso psila, T. Woods	K. or J.
Pyramidella jonesiana, Tate sp.	K. ?J.
Turbonilla weeahensis, Chapm. and Gabr.	K. ?J.
Eglisia triplicata, T. Woods sp.	K. ?J.
Calyptraea corrugata, Tate	K. ?J.
Calyptraea kalimnae, Chapm. and Gabr.	K. ?J.
Natica cunninghamensis, Harris	K. ?J.
Natica hamiltonensis, Tate	K. J.
Natica perspectiva, Tate	K. J.
Natica subinfundibulum, Tate	K.
Natica subinfundibulum, var crassa, Tate	K.
Natica substolida, Tate	K. (common). J.
Natica subvarians, Tate	(rare).
Natica wintlei, T. Woods	K.
Rissoa gatliffeana, Chapm. and Gabr.	J.
Rissoa varicifera, T. Woods	K.
Rissoa (Onoba) bassiana, Hedley	K. or J.
Rissoa (O.) chrysalida, Chapm. and Gabr.	K. ?J.
Turritella circumligata, Verco	K. ?J.
Turritella murrayana, Tate	?J.
Turritella pagodula, Tate	J.
Turritella platyspira, T. Woods	K. ?J.
Turritella tristira, Tate	K. J.
Cerithium torrii, Tate	K. J.
Tylospira coronata, Tate sp.	K.
Cassis contusus, Tate	K. ?J.
Cassis (Semicassis) subgranosa, Tate sp.	K.
Lotorium tortirostre, Tate sp.	K.
Lotorium tumulosum, Tate sp.	K. (basal bed).
Nassa spiraliscabra, Chapm. and Gabr.	J.
Zemira praecursoria, Tate	K.
Tudicla costata, Tate	?K. J.
Tudicla turbinata, Tate	J.
Fasciolaria rugata, Tate	K.
Marginella hordeacea, Tate	J.
Marginella muscarioides, Tate	K.
Marginella praeformicula, Chapm. and Gabr.	K. ?J.
Marginella wentworthi, T. Woods	K. ?J.
Voluta weldi, T. Woods	K. J.
Ancilla hebera, Hutton sp.	?K. J.

Name.	Geological horizons
Ancilla papillata, Tate sp.	K. ?J.
Terebra angulosa, Tate	K. or J.
Terebra geniculata, Tate	K. ?J.
Terebra profunda, Chapm. and Gabr.	K. ?J.
Terebra simplex, T. Woods	K.
Terebra subspectabilis, Tate	J.
Pleurotoma selwyni, Pritch.	K.
Pleurotoma trilirata, Harris	K. or J
Pleurotoma (Drillia) dilectoides, Chapm. and Gabr.	J. K.
Pleurotoma (D.) trevori, T. Woods sp.	J.
Bela sculptilis, Tate	J.
Tornatina aptycha, Cossmann	K.
Volvulella inflatior, Cossmann	K.
Bullinella aratula, Cossmann	K.
Vaginella cf. eligmostoma, Tate	?J.
Ostracoda—	
Argilloecia badia, G. S. Brady	J.
Macrocypris decora, G.S.B. sp.	K. J.
Macrocypris tumida, G.S.B.	K. J.
Bythocypris tumefacta, Chapm.	K. J.
Bairdia amygdaloides, G.S.B.	K. J.
Bairdia australis, Chapm.	K. J.
Cythere canaliculata, Reuss sp.	K. J.
Cythere crispata, G.S.B.	J.
Cythere dasyderma, G.S.B.	J.
Cythere demissa, G.S.B.	K.
Cythere dictyon, G.S.B.	K. J.
Cythere flexicostata, Chapm.	K. or J.
Cythere lactea, G.S.B.	?K. J.
Cythere lepralioides, G.S.B.	K. ?J.
Cythere lubbockiana, G.S.B.	K. J.
Cythere militaris, G.S.B. sp.	K. J.
Cythere normani, G.S.B.	?K. J.
Cythere obtusalata, G.S.B.	?K. J.
Cythere ovalis, G.S.B.	J.
Cythere parallelogramma, G.S.B.	?K. J.
Cythere postdeclivis, Chapm.	?K. J.
Cythere rastromarginata, G.S.B.	W. K. ?J.
Cythere scabrocuneata, G.S.B.	J.
Cythere scintillulata, G.S.B.	J.
Cythere scutigera, G.S.B.	J.
Cythere wyville-thomsoni, G.S.B.	K. or J.
Krithe eggeri, Chapm.	K.
Loxoconcha australis, G.S.B.	K. J.
Xestoleberis curta, G.S.B. sp.	K.
Xestoleberis margaritea, G.S.B.	J.
Xestoleberis variegata, G.S.B.	J.
Cytherura capillifera, Chapm.	K.
Cytherura ouyenensis, Chapm.	J.
Cytheropteron batesfordiense, Chapm.	?K. J.

Name.	Geological horizons.
Cytheropteron batesfordiense, var. aculeata, Chap. -	J.
Cytheropteron postumbonatum, Chapm. - -	K. or J.
Cytheropteron praeantarcticum, Chapm. - -	K.
Cytheropteron reticosum, Chapm. - - -	K.
Cytheropteron rostratum, Chapm. - - -	J.
Cytherella auriculus, Chapm. - - -	K.
Cytherella lata, G.S.B. - - - -	K. or J.
Cytherella polita, G.S.B. - - - -	K. J.
Cytherella pulchra, G.S.B. - - - -	K. J.
Cytherella punctata, G.S.B. - - - -	K. J.
Cytherella subtruncata, Chapm. - - -	K.
Cirripedia—	
Scalpellum subquadratum, Chapm. - - -	K. or J.
Balanus psittacus, Molina sp. - - -	K. or J.
Balanus varians, G. Sow. - - - -	K. J.
Decapoda—	
Chelae of crustacea, indet. - - - -	K. J.
Pisces—	
Cestracion cainozoicus, Chapm. and Pritch. -	K. or J.
Galeocerdo aduncus, Agassiz - - - -	K. or J.
Lamna compressa, Agassiz - - - -	J.
Carcharodon auriculatus, Blainv. sp. - -	K. or J.
Trygon cf. rugosus, Probst sp. - - -	J. (probably).
Myliobatis moorabbinensis, Chapm. and Pritch. -	K. ?J.
Chimaeroid teeth, indet. - - - -	J.
(?) Chrysophrys sp. - - - - -	?K. J.
Diodon formosus, Chapm. and Pritch. - -	K. ?J.
Teleostean fish otoliths - - - -	K. J.

EXPLANATION OF PLATES.

Plate VI.

Fig. 1.—*Argilloecia badia*, G. S. Brady. Right valve. Mallee Bore, No. 5, 189-190 feet. × 52.

Fig. 2.—*Macrocypris decora*, G. S. Brady sp. Right valve; specimen showing original colour markings. Mallee Bore, No. 9, 256-263 feet. × 52.

Fig. 3.—*Macrocypris tumida*, G. S. Brady. Right valve. Mallee Bore, No. 10, 310-320 feet. × 52.

Fig. 4.—*Bythocypris tumefacta*, sp. nov. *a*, Carapace seen from the right side; *b*, seen from below; *c*, end view, Mallee Bore, No. 11, 542-544 feet. × 40.

Fig. 5.—*B. tumefacta*, sp. nov. Another specimen (paratype), left valve. Mallee Bore No. 10, 310-320 feet. × 40.

Fig. 6.—*Bairdia amygdaloides*, G. S. Brady. Left valve. Mallee Bore, No. 10, 310-320 feet. × 52.

Fig. 7.—*Bairdia australis*, sp. nov. Right valve. Mallee Bore, No. 9, 256-263 feet. ×52.

Fig. 8.—*Cythere canaliculata*, Reuss sp. Right valve. Mallee Bore, No. 11, 219-260 feet. × 52.

Fig. 9.—*Cythere crispata*, G. S. Brady. Right valve. Mallee Bore, No. 11, 554-556 feet. × 52.

Fig. 10.—*Cythere dasyderma*, G. S. Brady. Left valve. Mallee Bore, No. 11, 554-556 feet. × 52.

Fig. 11.—*Cythere demissa*, G. S. Brady. Left valve. Mallee Bore, No. 10, 160-186 feet. × 52.

PLATE VII.

Fig. 12.—*Cythere dictyon*, G. S. Brady. Left valve of a youthful form, and well preserved. Mallee Bore, No. 9, 315-325 feet. × 40.

Fig. 13.—*C. dictyon*, G.S.B. Right valve of a senile form, with smoother and thicker carapace. Mallee Bore, No. 11, 438-440 feet. × 40.

Fig. 14.—*Cythere flexicostata*, sp. nov. *a*, Right valve; *b*, profile of valve seen from above. Mallee Bore, No. 10, 310-320 feet. × 52.

Fig. 15.—*Cythere lactea*, G. S. Brady. Right valve. Mallee Bore, No. 11, 562-564 feet. × 40.

Fig. 16.—*Cythere lepralioides*, G. S. Brady. Right valve. Mallee Bore, No. 8, 210-219 feet. × 52.

Fig. 17.—*Cythere lubbockiana*, G. S. Brady. Right valve. Mallee Bore, No. 11, 260-265 feet. ×52.

Fig. 18.—*Cythere militaris*, G. S. Brady sp. Right valve. Mallee Bore, No. 9, 256-263 feet. × 52.

Fig. 19.—*Cythere normani*, G. S. Brady. Right valve. Mallee Bore, No. 10, 310-320 feet. × 40.

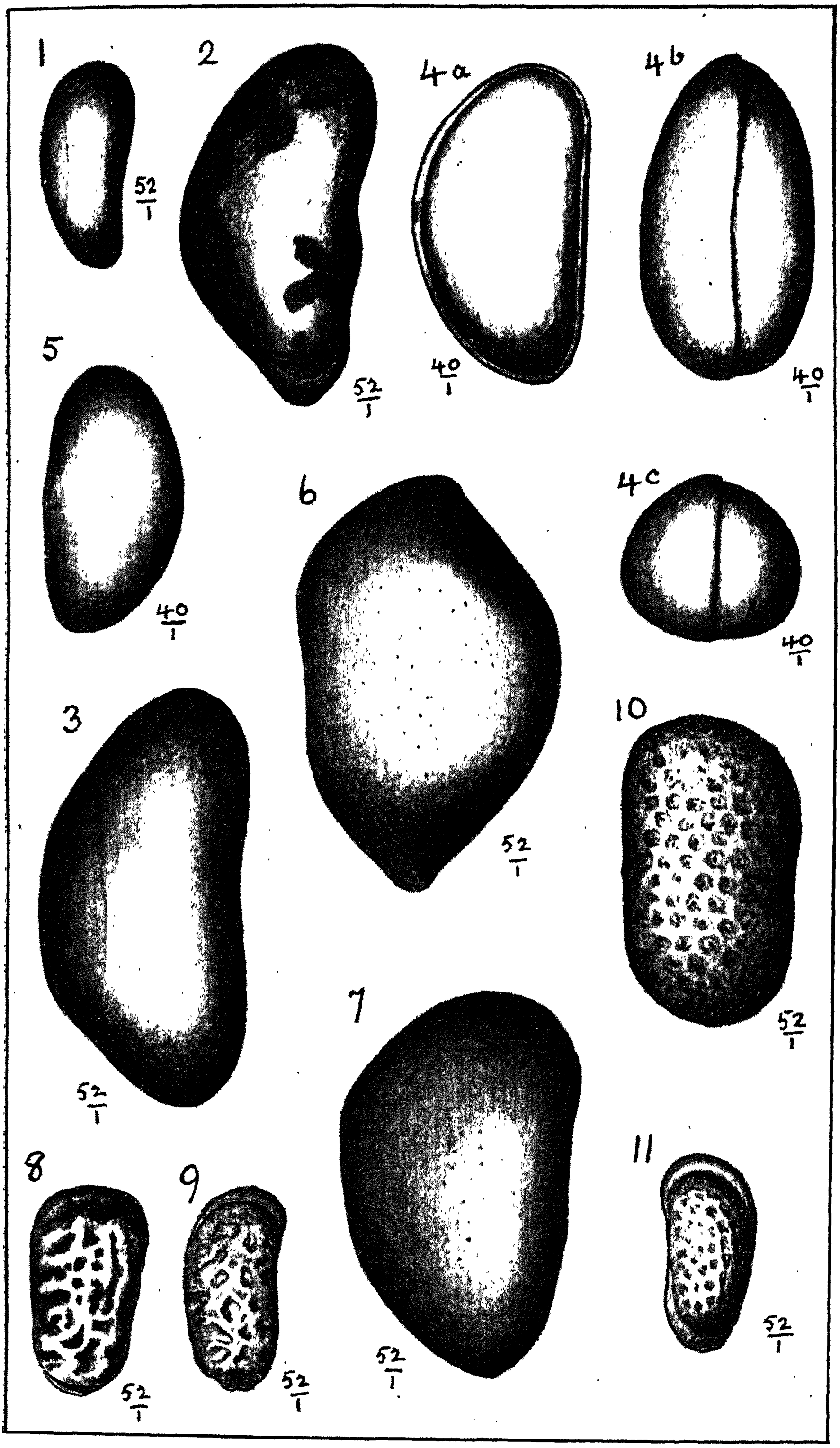
Fig. 20.—*Cythere obtusalata*, G. S. Brady. Right valve. Mallee Bore, No. 9, 256-263 feet. × 52.

Fig. 21.—*Cythere ovalis*, G. S. Brady. Left valve. Mallee Bore, No. 11, 276-270 feet. × 40.

Fig. 22.—*Cythere parallelogramma*, G. S. Brady. Left valve. Mallee Bore, No. 9, 315-325 feet. × 52.

Fig. 23.—*Cythere postdeclivis*, sp. nov. *a*, Left valve; *b*, profile of valve. Mallee Bore, No. 10, 310-320 feet. × 40.

Fig. 24.—*Cythere rastromarginata*, G. S. Brady. Right valve. Mallee Bore, No. 11, 170-175 feet. × 52.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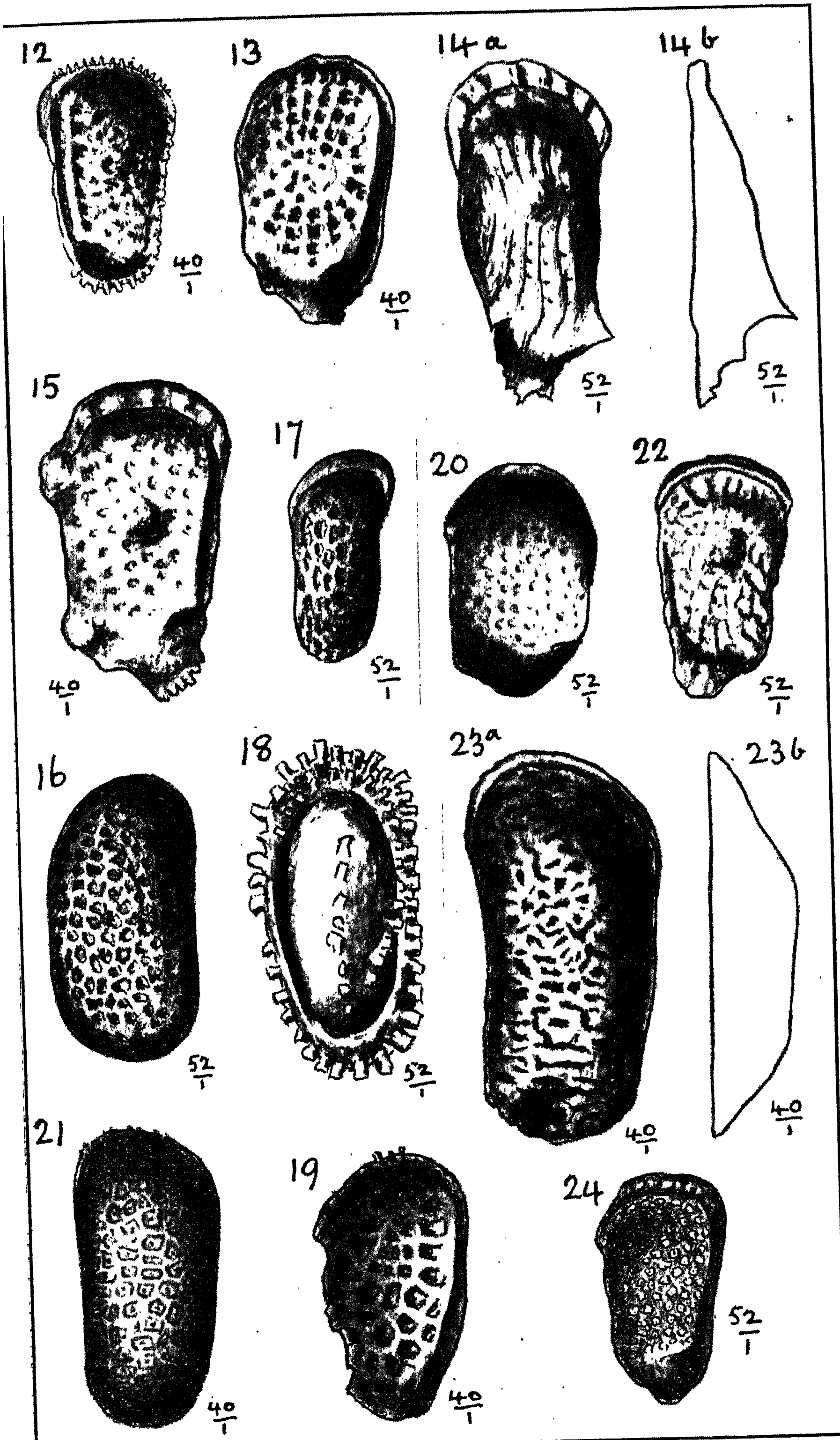
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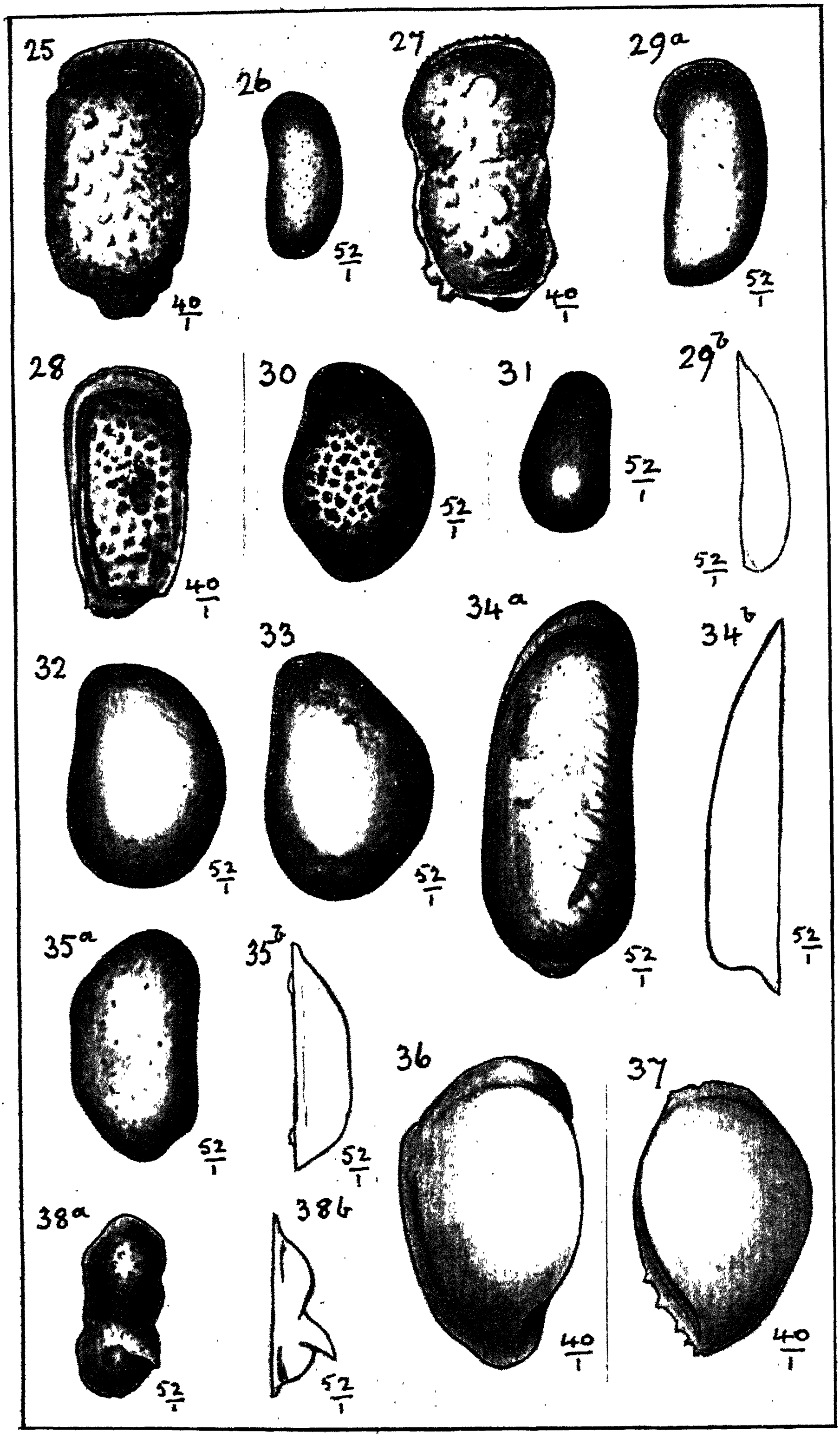
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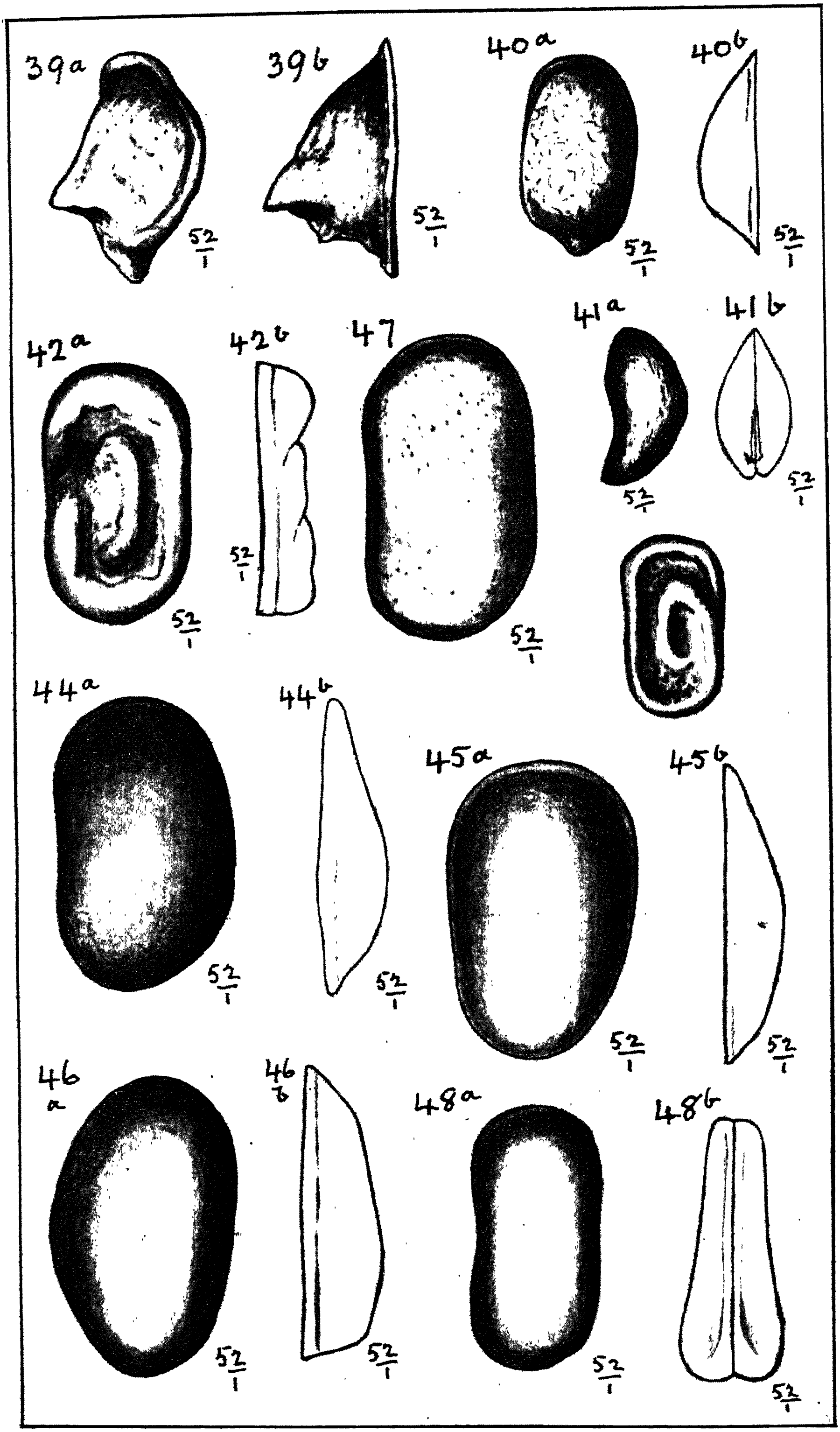
F.C. ad nat. del.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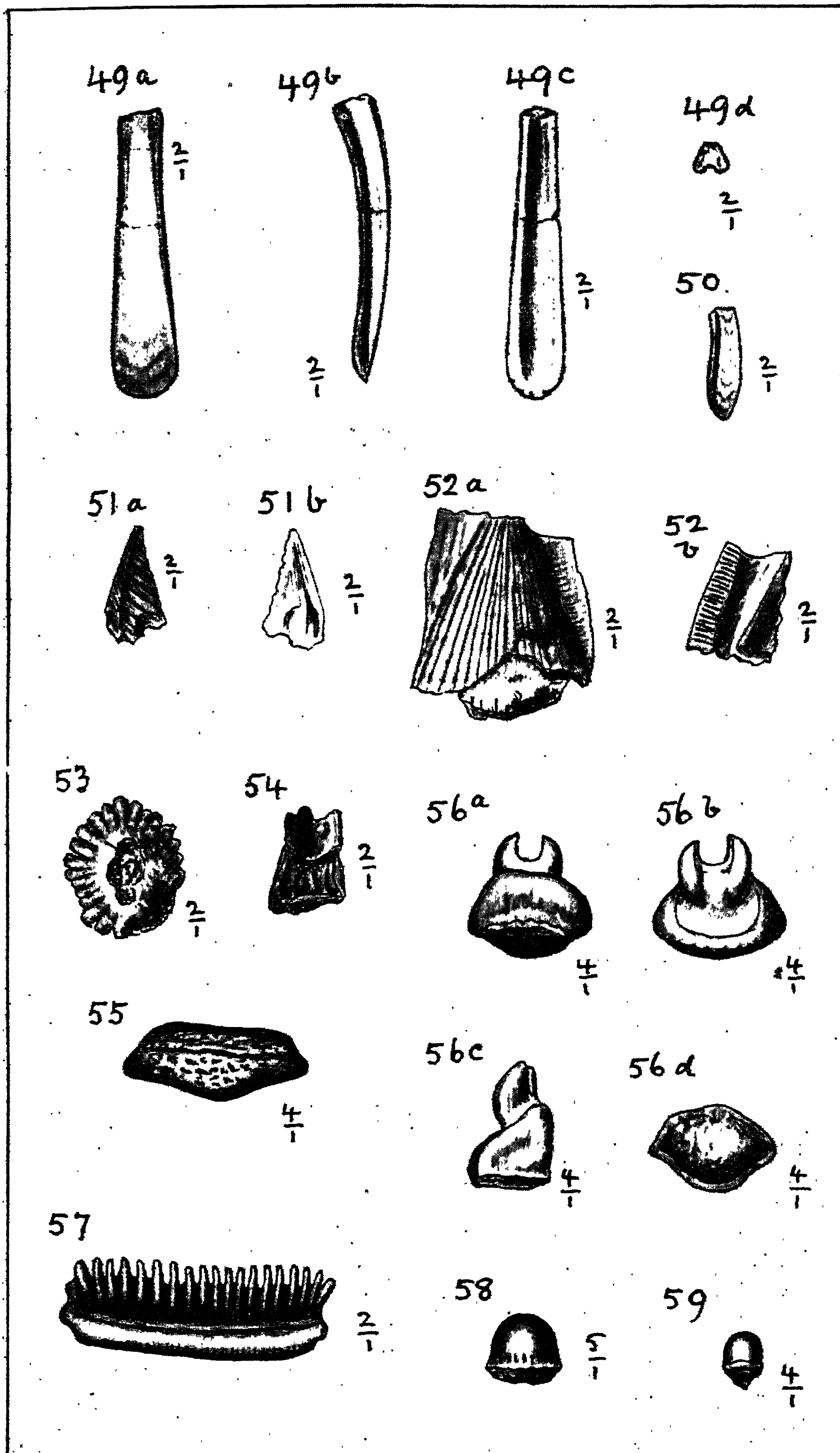
48a
48b

F.C. ad nat. del.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F.C. ad nat. del.

Plate VIII.

Fig. 25.—*Cythere scabrocuneata*, G. S. Brady. Right valve of a quadrate variety. Mallee Bore, No. 11, 457-458 feet. × 40.

Fig. 26.—*Cythere scintillulata*, G. S. Brady. Left valve. Mallee Bore, No. 5, 189-190 feet. × 52.

Fig. 27.—*Cythere scutigera*, G. S. Brady. Left valve. Mallee Bore, No. 5, 189-190 feet. × 40.

Fig. 28.—*Cythere wyville-thomsoni*, G. S. Brady. Left valve. Mallee Bore, No. 10, 310-320 feet. × 40.

Fig. 29.—*Krithe eggeri*, sp. nov. *a*, Left valve; *b*, profile, from below. Mallee Bore, No. 11, 260-265 feet. × 52.

Fig. 30.—*Lexoçoncha australis*, G. S. Brady. Left valve. Mallee Bore, No. 10, 225-230 feet. × 52.

Fig. 31.—*Xestoleberis curta*, G. S. Brady sp. Right valve. Mallee Bore, No. 10, 225-230 feet. × 52.

Fig. 32.—*Xestoleberis margaritea*, G. S. Brady. Left valve. Mallee Bore, No. 11, 267-270 feet. × 52.

Fig. 33.—*Xestoleberis variegata*, G. S. Brady. Left valve. Mallee Bore, No. 11, 267-270 feet. × 52.

Fig. 34.—*Cytherura capillifera*, sp. nov. *a*, Right valve; *b*, profile. Mallee Bore, No. 11, 175-197 feet. × 52.

Fig. 35.—*Cytherura ouyenensis*, sp. nov. *a*, Right valve; *b*, profile seen from above. Mallee Bore, No. 11, 267-270 feet. × 52.

Fig. 36.—*Cytheropteron batesfordiense*, Chapman. Right valve. Mallee Bore, No. 11, 440-442 feet. × 40.

Fig. 37.—*C. batesfordiense*, var. *aculeata*, var. nov. Left valve. Mallee Bore, No. 11, 453-454 feet. × 40.

Fig. 38.—*Cytheropteron postumbonatum*, sp. nov. *a*, Right valve; *b*, profile seen from below. Mallee Bore, No. 8, 210-218 feet. × 52.

Plate IX.

Fig. 39.—*Cytheropteron praeantarcticum*, sp. nov. *a*, Left valve; *b*, valve seen from above. Mallee Bore, No. 9, 256-263 feet. × 52.

Fig. 40.—*Cytheropteron reticosum*, sp. nov. *a*, Left valve; *b*, profile. Mallee Bore, No. 10, 195-225 feet. × 52.

Fig. 41.—*Cytheropteron rostratum*, sp. nov. *a*, Carapace seen from left side; *b*, profile from below. Mallee Bore, No. 11, 175-197 feet. × 52.

Fig. 42.—*Cytherella auriculus*, sp. nov. *a*, Left valve; *b*, profile. Mallee Bore, No. 11, 210-260 feet. × 52.

Fig. 43.—*C. auriculus*, sp. nov. Left valve of a young example. Mallee Bore, No. 11, 219-260 feet. × 52.

Fig. 44.—*Cytherella lata*, G. S. Brady. *a*, Left valve; *b*, profile. Mallee Bore, No. 5, 163-175 feet. × 52.

Fig. 45.—*Cytherella polita*, G. S. Brady. *a*, Left valve; *b*, profile. Mallee Bore, No. 9, 315-325 feet. × 52.

Fig. 46.—*Cytherella pulchra*, G. S. Brady. *a*, Right valve; *b*, profile. Mallee Bore, No. 10, 230-254 feet. × 52.

Fig. 47.—*Cytherella punctata*, G. S. Brady. Left valve. Mallee Bore, No. 9, 256-263 feet. × 52.

Fig. 48.—*Cytherella subtruncata*, sp. nov. *a*, Carapace seen from the left side; *b*, carapace seen from below. Mallee Bore, No. 10, 225-230 feet. × 52.

Plate X.

Fig. 49.—*Scalpellum subquadratum*, sp. nov. *a*, Carina, dorsal view; *b*, lateral view; *c*, interior of valve; *d*, section across posterior end of valve (Holotype). Mallee Bore, No. 4, 163-170 feet. × 2.

Fig. 50.—*S. subquadratum*, sp. nov. (?) Rostral latus (Paratype). Mallee Bore, No. 10, 310-320 feet. × 2.

Fig. 51.—*S. subquadratum*, sp. nov. Scutum: *a*, exterior; *b*, interior of valve (Paratype). Mallee Bore, No. 4. 163-170 feet. × 2.

Fig. 52.—*Balanus psittacus*, Molina sp. Rostral compartment: *a*, exterior; *b*, interior, showing strongly denticulated septa of the radii. Mallee Bore, No. 9, 315-325 feet. × 2.

Fig. 53.—*Balanus varians*, G. S. Sowerby. A complete base. Mallee Bore, No. 9, 315-325 feet. × 2.

Fig. 54.—*B. varians*, Sowerby. A carinal valve. Mallee Bore, No. 9, 315-325 feet. × 2.

Fig. 55.—*Cestracion cainozoicus*, Chapman and Pritchard. Anterior lateral tooth. Mallee Bore, No. 8, 210-219 feet. × 4.

Fig. 56.—*Trygon* cf. *rugosus*, Probst sp. *a*, Anterior aspect of tooth; *b*, posterior aspect; *c*, side view; *d*, upper surface of tooth. Mallee Bore, No. 5, 163-175 feet. × 4.

Fig. 57.—*Myliobatis moorabbinensis*, Chapman and Pritchard. Lower or articulated surface of tooth. Mallee Bore, No. 10, 225-230 feet. × 2.

Fig. 58.—(?) *Chrysophrys* sp. Rounded pavement tooth; with crenulated basal margin. Mallee Bore, No. 8, 210-219 feet. × 5.

Fig. 59.—(?) *Chrysophrys* sp. Tooth with thickened basal margin. Mallee Bore, No. 3, 201-220 feet. × 4.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART I., 1914].

ART. VII.—*Further Notes on Australian Hydroids.—III.*

BY W. M. BALE, F.R.M.S.

(With Plates, XI., XII., XIII.).

[Read 9th July, 1914].

ORTHOPYXIS, L. Agassiz.

Campanularia, auct., in part.
Clytia, auct., in part.
Laomedea, auct., in part.
Eucopella, Von Lendenfeld, in part.
Agastra, Hartlaub.

Trophosome consisting of smooth or undulated peduncles of varying length, springing from a creeping hydrorhiza, and supporting each a single hydrotheca; hydrothecae campanulate, with the lower part compressed, but usually circular above, the perisarc varying much in thickness, but always greatly thickened inwards near the base so as to form a "floor" on which the hydranth is supported; hydranth radially symmetrical, with about 24-32 tentacles and a large trumpet-shaped hypostome.

Gonothecae very variable in form within the limits of a species; gonozooid a modified medusa, having neither tentacles nor digestive cavity, but provided with four branched radial canals, and sometimes with marginal sense-organs.

The sub-genus *Orthopyxis*, which was proposed by Agassiz for the reception of the single species *Clytia* (*Orthopyxis*) *poterium* (a species which had already been described by Hincks under the name of *Campanularia caliculata*), has been disregarded by later observers, most of whom have been content to rank the species under *Clytia* or *Campanularia*.

In 1883 Von Lendenfeld described as the type of a new genus and family a species which he called *Eucopella campanularia*, and which, he claimed, was distinguished from all previously known hydroids by the possession of a gonozooid medusoid in character but totally destitute of manubrium and tentacles. Although referring to Agassiz' work he failed to notice that the characters on which he based his new genus were precisely those of the form described in great detail by the American naturalist.

In recent years several observers have, following Von Lendenfeld, admitted the genus *Eucopella*, and Fraser, recognising the affinity of *C. caliculata* with Von Lendenfeld's genus, has adopted the name *Eucopella caliculata*. No doubt Fraser is right with regard to the affinity of that species, but if such forms are to be separated from *Campanularia* or *Clytia* (as most observers seem inclined to separate them), then they must be referred to *Orthopyxis*, which was far anterior to Von Lendenfeld's genus. That *Eucopella* should be superseded is the more desirable, since much confusion has been caused by the original association under that name of two quite unrelated forms.

The most important character of the genus *Orthopyxis* is the structure of the gonozooid, which, as described by Agassiz, is a very degraded form of medusa, having an umbrella with four radial canals, but neither manubrium nor tentacles. There is also a peculiarity of the trophosome not noticed by any of the earlier observers, namely the distinctly bilateral development of the hydrotheca, which is compressed in the lower half so as to be of an elliptic or oblong section, while, as a rule, retaining the ordinary circular form in the distal portion. Another prominent characteristic, apparently common to all the species, is the variability in thickness of the hydrotheca-wall, which occurs in individuals not only of the same variety, but also of the same colony. I find this variation in thickness to be dependent, to a certain extent, on the position in which the hydrotheca is viewed; thus a hydrotheca seen in its broader aspect is not only less tapering downwards, with a wider and flatter floor, but its wall commonly appears distinctly more thickened than when it is seen in its narrow aspect. In some of the published figures of *O. compressa* the thickening of the calycle-wall is remarkably developed.

In *O. caliculata* the peduncles, which vary extremely in length, are slender, thin-walled, and twisted into a loose, irregular spiral, generally throughout their length, but sometimes with smooth or nearly smooth intervals. Most of the other forms agree in this particular, or else have the undulations shorter and more pronounced, but *O. compressa* and *O. angulata* have peduncles which are stouter in themselves, and provided with thicker perisarc, and never exhibit the spiral or undulated form found in the other species. Below the pronounced globular segment which occurs immediately under the hydrotheca in all the species, these often have a distinct oblong segment, and there may be a few constrictions at irregular intervals.

A noteworthy characteristic of the genus is the wide range of variation displayed in the forms of the gonangia. Every species has its typical form, but a large proportion of the individual gonangia differ from their respective types very considerably, distorted and irregular forms being abundant. Several species which scarcely differ at all in regard to the trophosome have nevertheless gonangia quite unlike each other.

Only in *O. caliculata* and *Eucopella campanularia* have the gonozooids been the subject of elaborate investigations, the former by Agassiz and the latter by Von Lendenfeld. The most important distinction is the presence in *E. campanularia* of eight otocysts on the umbrella-margin. So far as is known there is no noticeable difference in any of the species between the gonangia which contain the male and the female medusae.

Perhaps the most striking point about the genus is the exceedingly close relationship existing between the various species. Except for the difference in the peduncles, which distinguishes *O. compressa* and *O. angulata* from the other forms included here, their trophosomes agree so closely that, keeping in mind the variations which exist in each species (and which will most probably be found on further investigation to be even more extensive than I have described them from the few specimens at my disposal), we would not find it surprising if all these variations were to occur within the limits of a single species. Yet the differences in the gonosomes appear ample to justify their separation. It is to be borne in mind, however, that most of these species are described from the trophosomes and the gonangia only; in none of them except *O. caliculata* and *E. campanularia* have the gonozooids themselves been sufficiently investigated to render it certain that they come strictly within the limits of the genus as it is described by Agassiz and Von Lendenfeld.

Orthopyxis caliculata (Hincks). (Pls. XI. and XII., Fig. 1).

Campanularia caliculata, Hincks, Ann. Mag. Nat. Hist. (2), xi., 1853, p. 178, pl. v., fig. 5. Allman, Proc. Roy. Soc. Edin., iv., 1862, p. 61, 64. Hincks, Brit. Hyd. Zooph., 1868, p. 164, pl. xxxi., fig. 2-2d. Bale, Proc. Lin. Soc. N.S.W. (2), iii., 1888, p. 755, pl. xiii., figs. 1-3. Schneider, Zool. Jahrb., x., 1897, p. 482. Thornely, Zool. Results, Willey, iv., 1900, p. 454. Hargitt, Amer. Nat., xxxv., 1901, p. 383, fig. 18. Hartlaub,

Zool. Jahrb., Suppl. vi., 1905, p. 560, 553, 562, figs. K, L. Warren, Ann. Nat. Govt. Mus., i., 1908, p. 338, f. 19.

Campanularia breviscyphia, Sars, Middelhavet's Lit. Fauna, 1857, p. 158, pl. i., figs. 12-13.

Laomedea caliculata, Allman, Ann. Mag. Nat. Hist. (3), xiii., 1864, p. 373.

Clytia (Orthopyxis) poterium, Agassiz, Contr. Nat. Hist. U.S., iv., 1862, p. 297, pl. xxviii., figs. 1-20, pl. xxix., figs. 1-5.

Orthopyxis poterium, A. Agassiz, Catal. N. Amer. Acal., 1865, p. 81.

Campanularia poterium, Nutting, U.S. Fish. Comm. Bull. for 1899, 1901, p. 344, fig. 24.

Clytia caliculata, Nutting, Proc. Wash. Acad. Sci., iii., 1901, p. 170, pl. xvii., fig. 1-2.

Eucopella caliculata, Fraser, Bull. Labor. N. H. State Univ. Iowa, vi., 1911, p. 36.

Campanularia integra, in part, Levinsen, Vid. Meddel. fra den naturh. Foren, 1892, p. 26. Marktanner-Turneretscher, Zool. Jahrb., viii., 1895, p. 406. Birula, Ann. Mus. Zool. Acad. Sc. St. Pétersbourg, 1898, p. 3-6, fig. 1-3. Billard, Arch. de Zool, exp. et gén. (4), vii., 1907, p. 340. Jâderholm, Kungl. Svensk. Vetenskaps-akad. Handling., Bd. 45, 1909, p. 65. Broch, Fauna arctica, v., 1909, p. 185, 225. Linko, Faune de la Russie, i., 1911, p. 170.

(Not *Campanularia caliculata*, Calkins, Proc. Boston Soc. Nat. Hist., xxviii., 1899, p. 351, pl. ii., fig. 11-11c., pl. vi., fig. 11d.)

This cosmopolitan species has been often described, but all the older descriptions missed an important point in the structure of the hydrotheca, namely the bilateral development of the lower portion, which is distinctly compressed, so that the hydrothecae at this part may be said to have two broader and two narrower sides. I have generally found the perisarc of the narrower sides somewhat thicker than elsewhere, so that on viewing the hydrotheca in its broader aspect the wall appears thicker than when seen in the other direction. In a typical hydrotheca, as seen in its narrow aspect, the two sides appear as convergent lines, straight throughout, the outline in this aspect being therefore distinctly funnel-shaped. But

as seen in the other aspect the sides are less convergent down to the floor or diaphragm, below which they curve inward, making the outline bell-shaped. The thickening of the calycle-wall may be quite pronounced in the broader view, while not appearing in the narrower aspect. This thickening is generally greatest at the margin of the hydrotheca, becoming gradually less towards the diaphragm. The conspicuous inward thickening which forms the diaphragm is pierced by a central channel, or hydropore, which expands into a small rounded cavity between the diaphragm and the base of the hydrotheca. If the same hydrotheca be viewed in its narrow aspect the sides will appear quite thin, and even at the base the perisarc will not appear very thick, as the central enlargement of the hydropore appears in this view to nearly fill the space below the diaphragm. But in some colonies all the hydrothecae may appear thin-walled, in whatever direction they are viewed.

Sometimes the border of the hydrotheca may be a little everted, in other cases not at all, especially when thick at the margin. Considerable differences in size often exist among the hydrothecae of a single colony. I have not detected any sign of bilateral symmetry in the hydranths, which have a very large hypostome and from about 24 to 30 tentacles. The peduncles may be of any length, from twice that of the hydrothecae to twenty times, or even more. They are thin-walled, and twisted in a loose irregular spiral, with occasionally smooth interspaces.

The typical gonangia are oblong or ovate, tapering below, smooth, and when mature rounded at the top. They are but slightly compressed. But variations from the type are abundant; sometimes there are two inflations, corresponding to the two contained zooids, in other cases there are still more irregular forms, and there may be a series of annular undulations. Agassiz describes the gonothecae as about twice the length of the hydrothecae; in my specimens I find them three to four times as long.

Much difference of opinion exists as to whether *O. caliculata* and *O. integra* are the same species. Among those who support this view are Levinsen, Birula, Billard, and Linko, while Hartlaub, Calkins, and Nutting hold the contrary opinion. I am at the disadvantage of not having seen Birula's paper, but I find from Linko that *C. integra, forma typica*, is distinguished by its orbicular and thin-walled hydrothecae from *forma caliculata*, in which the hydrothecae are compressed, with thick walls. This distinction obviously does not hold good, since we find the compressed hydro-

thecae of *O. caliculata* are frequently quite as thin-walled as those of *C. integra*. However, it is admitted that *O. caliculata* has the hydrothecae compressed while *C. integra* has not, and in face of that fact it would require very strong evidence to prove the identity of the two forms. It may be mentioned that Calkins claims to be able to distinguish between them by the diaphragm, which in *O. caliculata* is simply the inward thickening of the perisarc, while in *C. integra*, according to this observer, there is a special diaphragm overlying the perisarcal thickening. Broch (Bergens Museum Aarbog 1905, No. 6, p. 10, fig. 1), describes and figures this character as pertaining to *C. caliculata*, but nothing of the sort exists in any specimen of *C. caliculata* observed by me, nor indeed in any of the species ascribed in this paper to the genus *Orthopyxis*.

ORTHOPYXIS MACROGONA, (Von Lendenfeld). (Pls. XI. and XII., Fig. 2).

Campanulina calyculata var. *makrogona*, Von Lendenfeld, Proc. Lin. Soc. N.S.W., ix., 1884, p. 922.

Campanularia caliculata var. *makrogona*, Bale, Proc. Lin. Soc. N.S.W. (2), iii., 1888, p. 755, pl. xiii., fig. 4-8. Farquhar, Trans. N.Z. Inst., xxviii., 1895, p. 459.

Hydrorhiza very stout, peduncles slightly to strongly waved, three or four times as long as the hydrothecae.

Hydrothecae very much compressed, with the aperture circular or elliptic; in the broad aspect with very wide base and with the cavity usually equally wide from the aperture to the floor, which is quite flat; in the narrow aspect with a somewhat abrupt decrease of diameter about the middle; wall-thickening in the form of a stout convex external band completely surrounding the upper half of the hydrotheca; margin plain, slightly everted. Length .28—.45 mm.; width of the broad side at aperture .22—.28 mm.

Gonothecae very large, oblong or ovate, often irregular, smooth, rounded above, very slightly compressed; length about 1.65—1.87 mm., width, .82—.90 mm. Gonophore a medusoid bud, not becoming free.

Hab.—Port Phillip (Von Lendenfeld); New Zealand (Farquhar); Bondi (Australian Museum).

The character which led Von Lendenfeld to distinguish the variety was the very large size of the gonangia, which otherwise much resemble those of *O. caliculata*, being like them, subject to extreme variation in form. They are of very firm perisarc. The hydro-

thecae are more compressed laterally than those of *O. caliculata*, and in most of them the sides, in the broader aspect, are not convergent, so that in this view the cavity appears as if perfectly cylindrical, with a flat floor. A much thickened annular band, convex in section, encircles the distal half of the hydrotheca completely; from the lower edge of this band to the floor the wall is less thickened. The hydrothecae frequently have the compressed condition extended in some degree to the distal portion, so that the aperture may be elliptical. The bead-like segment immediately below the hydrotheca is noticeably narrower than the peduncle on which it is supported, a feature not observable in *O. caliculata.*

The rounded summit of the gonotheca forms a convex cap, which separates at maturity. There are usually two gonozooids, which are described by Von Lendenfeld as medusoid buds, which do not become free, and in fact do not possess a properly developed umbrella at the time when the sexual products are matured. He adds that they are similar to those of *C. caliculata.*

ORTHOPYXIS WILSONI n. sp. (Pls. XI. and XII., Fig. 5).

Hydrorhiza rather slender, peduncles strongly waved, commonly 2-4 times as long as the hydrothecae.

Hydrothecae usually thin-walled, but occasionally slightly thickened, thickening principally near the top; mostly somewhat bell-shaped in the broad aspect, rather more funnel-shaped in the narrow view, with the thickening absent or scarcely indicated; border plain, very slightly everted: length, .34—.43 mm., width at aperture, .25—.33 mm.

Gonothecae very large, not compressed, sub-cylindrical, equal in diameter throughout except at the basal part, divided into about seven or eight longitudinal areas by lines which run from the summit to near the base; no operculum, irregular forms frequent. Length when mature, about 1.95 mm., diameter, .75—.87 mm. Gonophores large, medusoid, umbrella with 8 otocysts (?).

Hab.—Port Phillip (Mr. J. Bracebridge Wilson).

Many of the hydrothecae show no thickening, others appear in the broader aspect slightly thickened in the fashion of *O. caliculata*, or with a sub-marginal band in the same position as that of *O. macrogona* but much less pronounced. The two aspects differ but little, the cavity being somewhat more broadly rounded at the base in one view than in the other. The peduncles usually have the

undulations shorter and more strongly accentuated than those of *O. caliculata*. The gonangia are of very characteristic form. They roughly resemble a seven- or eight-sided prism, but the sides are curved instead of flat. The longitudinal lines are simply the optical expression of the folds in the perisarc, where the sides meet. These lines usually appear more or less irregular, being broken and wanting in parts, and in comparatively few cases are they fairly straight and uniform throughout. The gonotheca is subject to quite as many irregularities as in the allied species; I have seen examples with a deep constriction round the middle, and others with a series of irregular annulations. The sexes do not differ in form. There are two medusae, one of which may be so large as to nearly fill the capsule, while the other is still very small. In one case I saw what seemed to be otocysts.

The absence of a distinctly compressed condition of the gonangia differentiates this species from all the others referred to in this paper.

ORTHOPYXIS PLATYCARPA n. sp. (Pls. XI. and XII., Fig 3).

Hydrorhiza stout, peduncles distinctly waved, mostly 2-4 times as long as the hydrothecae.

Hydrothecae large, wide-based in the broader aspect, with the walls often somewhat thickened, principally in the form of a convex sub-marginal band, narrower aspect less thickened or not at all, border plain, distinctly everted. Length, .33—.43 mm., width at border, .32—.39 mm.

Gonothecae large, very much compressed, smooth, with straight sides forming angles at the summit, which is slightly lower between them, a single gonophore filling the capsule when mature. Length, about 1.55 mm., width .72—.90.

Hab.—In or near Port Phillip.

This form, in the strongly compressed hydrothecae, the broad basal portion, and the form of the thickening, shows most affinity with *O. macrogona*, and occasionally a hydrotheca is seen which might readily be taken for one of that species. The gonangia, however, differ greatly in their straight sides and squarish summit (as seen in their broader aspect), and in their much compressed form. Seen edge-wise they appear slightly curved alternately in opposite directions. In each of the few specimens which I examined there was a single large gonophore, occupying the whole cavity, but they were not in a condition to permit of their character being made out satisfactorily.

I have seen but few gonangia, and cannot say what may be the extent of their habitual variation. Those which appear typical somewhat resemble those of *O. angulata*, but that species is readily distinguishable from the present by its smooth peduncles.

ORTHOPYXIS COMPRESSA Clark.

Campanularia compressa, Clark, Proc. Acad. Nat. Sci. Philad., 1876, p. 214, pl. viii., fig. 5, 6. Hartlaub, Zool. Jahrb., Suppl. vi., 1905, Bd. iii., p. 562, fig. M, Linko, Faune de la Russie, Hydroidea, i., 1911, p. 172, fig. 29.

Clytia compressa, Nutting, Proc. Wash. Acad. Sci., iii., 1901, p. 170, pl. xvii., fig. 3, 4. Vanhöffen, Deutsche Südpolarexp. 1901-3, xi., Zool. iii., 1910, p. 303, fig. 24-24e.

Eucopella campanularia, Von Lendenfeld, Zeitschr. f. wiss. Zool., xxxviii., 1883, pp. 497-583, pl. xxvii-xxxii. (but not pl. xxix., fig. 15, D1, D½).

? *Campanularia caliculata*, Calkins, Proc. Bost. Soc. Nat. Hist., xxviii., 1899, p. 351, pl. ii., fig. 11-11c, pl. vi., fig. 11d.

? Not *Campanularia compressa*, Jäderholm, Schwedischen Südpolarexp. 1901-3, v., 1905, p. 14, pl. v., fig. 6, 7.

Not *Clytia compressa*, Torrey, Univ. Calif. Publ., Zoology, i., 1902, p. 58, pl. vi., fig. 49.

O. compressa has the hydrothecae of the same type as those of *O. caliculata*, but they have the perisarcal thickening more pronounced. Most observers figure thick-walled and thin-walled hydrothecae, which are probably different aspects of the same individual. The chief distinction between this species and *O. caliculata* is in the peduncles. These in *O. caliculata* are twisted in a somewhat irregular spiral; the undulations may fail here and there, but are rarely absent altogether. In *O. compressa* the stalks are much stouter, with thicker walls, while they are never undulated, though they may be divided, especially near the hydrotheca, by several distinct constrictions. Their thick perisarc appears narrowed in at the point of origin, so that their diameter at this point is little more than that of the internal canal, and altogether they closely resemble those of the genus *Silicularia*.

Various forms of gonangia have been figured, some cuneate, others more elongated; Clark describes them as "largest at the

distal end, rounded at the base, very much compressed laterally." Vanhöffen's and Linko's figures show them with the perisarc very much thickened towards the base, exactly as in those of *Silicularia reticulata* (Hartlaub), which they also resemble in their cuneate outline.

Contradictory accounts of the species are given by different observers. Nutting, Hartlaub, Vanhöffen, and Linko appear to have seen specimens agreeing with Clark's. Calkins describes under the name of *Campanularia caliculata* a form of which the trophosome, according to his account, agrees exactly with that of *O. compressa*, not with that of *O. caliculata*. At the same time the gonangia which he figures are more like those of the latter species. Torrey describes specimens of which the medusa has four long tentacles, as however the hydrothecae have a toothed margin, which never occurs in *O. compressa*, it is difficult to see why they are referred to that species. The form given as *C. compressa* by Jäderholm has ringed or twisted peduncles, and therefore seems wrongly placed; the gonotheca moreover is more like that of *O. caliculata*. As Vanhöffen states, the species is characterised by the thick hydrothecae, the smooth stalks, and the broad flat gonothecae.

In ranking *Eucopella campanularia* Von Lendenfeld as a synonym of *O. compressa* I follow Nutting, who has pointed out in his paper on the Hydroids of the Harriman Alaska Expedition that there appears to be no difference between the two species. *E. campanularia*, however, has been involved in some confusion owing to Von Lendenfeld's having included in his account of the species two forms differing entirely in regard to the hydrothecae, though the gonangia are similar. He has figured a number of hydrothecae which he says are connected by intermediate forms; most of these are of the ordinary *Orthopyxis* type, but two among them are of totally different form, and are obviously identical with those found in the genus *Silicularia*. No intermediate forms between these and the *Orthopyxis* are shown. In 1886 I received from the Australian Museum a portion of the type specimens of *E. campanularia*, which consisted solely of the *Silicularia*-forms, and were similar to those figured by me as *E. campanularia* in the Proceedings of the Linnean Society of N.S. Wales for 1888. I had not then seen Von Lendenfeld's original paper, and was not aware that any other form had been included in the species. Neither in the type specimens sent to me nor in any others of similar character which I have examined, is there any approach to the *Orthopyxis* type, while colonies of the

latter invariably fail to exhibit any hydrothecae with characters tending towards the *Sicilularia* form. The distinction between the trophosomes is absolute, and I consider it beyond a doubt that *Eucopella campanularia*, as originally described, comprises two distinct species, one a typical *Orthopyxis*, the other, at least so far as the trophosome is concerned, a typical *Silicularia.*

The account of the gonangia of *E. campanularia* is contradictory, their length being stated as from two to three millimetres, while they are figured as under .75 mm.; but their compressed condition, and their cuneate outline, as seen in their broader aspect, are quite similar to the same features in the typical *O. compressa.* Only, therefore, in the event of future research revealing some important difference between the gonozooid of that species and Von Lendenfeld's description will be possible to maintain the specific distinctness of *E. campanularia.*

O. compressa is found in North and South America, where, like Von Lendenfeld's specimens, is appears to grow habitually, if not exclusively, on Laminaria.

Orthopyxis angulata, n. sp. (Pls. XI. and XII., Fig. 4).

Hydrorhiza thick and broad, peduncles stout, with thick perisarc, smooth, occasionally with one or more distinct constrictions, narrowed in at the base.

Hydrothecae, in the broader aspect, very wide at the base, with the floor somewhat flattened, often more or less thickened, thickening sometimes confined to a convex band surrounding the distal portion of the hydrotheca, sometimes extending to the base; narrow aspect funnel-shaped, with thin walls, except for a slight thickening where the sub-marginal band extends to them; margin plain, everted. Length, .36—.45 mm., width at aperture, .27—.37 mm.

Gonothecae broad, much compressed, the broad aspect ovate, truncate, with edges undulated; a little narrowed in near the top, and then widening outward and upward, forming angular projections at each side of the top, or even produced into blunt, horn-like processes, summit of the gonangium straight or slightly concave between them. Length, about 1.27—1.36 mm., width, .87—.96 mm. Two gonophores in each gonotheca; umbrella with four branching radial canals, and eight otocysts.

Hab.—Port Phillip (Mr. J. Bracebridge Wilson).

This species agrees with *O. compressa*, and differs from the other forms here described, in the stout, thick-walled, smooth peduncles.

The hydrothecae as seen in the broader aspect, are wider-based than any other form except *O. macrogona*, with the wall often considerably thickened at the border, and continuing fairly thick down to the base; or in some cases the thickening is confined to the upper part, forming a convex band like that of *O. macrogona*, but not so pronounced. The narrow aspect is funnel-shaped, with no thickening except a very slight one in the sub-marginal region. The border generally rises a little above the thickened part, and is distinctly everted.

The gonangia are broad, but rather short, their height averaging about 1.3 mm., and their width .90. They are ovate, truncate above, and much compressed; in the broad view the edges are undulated, curving inward near the top, and then outward, forming where they meet the top blunt angles, which are usually produced somewhat outward and upward. The summit of the gonangium is slightly concave or nearly flat, and so narrow that an end view would be lanceolate rather than elliptic. Irregular forms are found, but most of those examined were normal. Two gonozooids are contained, pretty closely packed, the lower one larger in proportion to the upper than is usually the case, and lying obliquely to it. The only gonangia seen contained male gonozooids. The eight otocysts of the medusa were very distinct.

A very close affinity exists between the present species and *Eucopella campanularia* Von Lendenfeld (which is discussed under *O. compressa*). The principal difference is in the form of the gonangia, which are distinguished from those of *E. campanularia* by the broader lower portion, the undulated outline, and particularly by the prominent superior angles.

SILICULARIA, Meyen.

Hypanthea, Allman.

Eucopella, in part, Von Lendenfeld, Hartlaub.

Allman's description of the genus *Hypanthea* is as follows:—"Hydrothecae pedunculate, inoperculate, with walls enormously thickened, and so far encroaching upon the cavity as to render impossible the complete retraction of the hydranth. Gonosome—Gonangia enclosing fixed sporosacs." The species were further characterised by the possession of bilateral hydrothecae, with oblique apertures. A more recently described species, however,—*S. divergens* Hartlaub—differs from all the others in having the hydrothecae regular, with a large cavity, and apparently resembling those of

Orthopyxis. Probably these may be bilateral to the same extent as those of *Orthopyxis;* in any case they seem to form a distinct link between the two genera.

As stated under *O. campanularia* Von Lendenfeld included under that species two distinct hydroids, an *Orthopyxis*, and a *Silicularia*, the latter of which is here distinguished under the name of *S. campanularia*.

In considering the relations of *Orthopyxis* and *Silicularia* we must not overlook the different structure of the hydranths. Those of *Orthopyxis* are, so far as an ordinary examination can disclose, purely radial, while some species at least of *Silicularia* are distinctly bilateral, as described by Hilgendorf in his *H. asymmetrica*, and as they exist in Von Lendenfeld's specimens, and are indicated by Hartlaub in *E. reticulata*. A large lobe or inflation occupies that side of the hydrotheca, which is lower than the rest, apparently to accommodate it, and as all species of *Silicularia* (except *S. divergens*), also have one side lower, it is presumable that the structure of the hydranth is similar in all of them. Another peculiarity in our specimens is the union of the proximal part of the tentacles in a sort of calyx with an annular, thickened border, and of this also there is a distinct indication in Hartlaub's figure of *E. reticulata*.

SILICULARIA CAMPANULARIA (Von Lendenfeld). (Pl. XIII., Figs. 1-6).

Eucopella campanularia, in part, Von Lendenfeld, Zeitschr. f. wiss. Zool., v., 1883, p. 497-583; pl. xxix., fig. 15, D1, D½.

Eucopella campanularia, Bale, Proc. Lin. Soc. N.S.W., (2), iii., 1888, pl. xiii., figs. 9-15. Mulder and Trebilcock, Geelong Naturalist, (2), vi., 1914, p. 9, pl. ii., figs. 8-11.

? *Eucopella reticulata*, Hartlaub, Zool. Jahrb., Suppl. vi., iii., 1905, p. 569, fig. R1.

Hydrorhiza very broad and thick-walled, with numerous branches, which are mostly given off at right angles, and are commonly opposite. Peduncles very stout, and with thick perisarc, the longer ones sometimes a little attenuated in the middle, rounded at the top, and narrowed in at the base, one or two rounded or oblong segments sometimes at the top, a distinct rounded or angular bead between the peduncle and the hydrotheca.

Hydrothecae much compressed, the two broad sides forming erect convex lobes, the intermediate sides lower, forming two lips, one lower than the other; the interior nearly filled up with solid perisarc, pierced by the hydropore, which is enlarged just above its lower extremity, and gradually widens out above into the shallow cavity of the hydrotheca.

Gonothecae usually decumbent, cuneate, compressed, rounded at the top when mature, shortly but distinctly stalked, their perisarc thickened towards the base.

Hydranths seated in the concavity of the hydrothecae, base flattened, a large rounded retractile inflation of that side of the body which is over the lower lip; proximal portion of the tentacles united and joined by an annular band into a calyx surrounding the oral extremity.

Gonophores—sporosacs, one or two in each gonotheca.

The foregoing description refers to the specimens which formed part of Von Lendenfeld's types of *Eucopella campanularia,* and which, as already mentioned, were sent to me from the Australian Museum. The description applies equally to the two forms from Bondi figured by me in the Proceedings of the Linnean Society of New South Wales, under the name of *E. campanularia.* There are slight differences among these forms, and as there may be a doubt as to whether they should all be classed together, I now figure the actual specimens taken from Von Lendenfeld's types. The relationship between these three forms, also *Eucopella reticulata* Hartlaub, is very close.

In Von Lendenfeld's specimens the hydrorhiza is extremely broad, reaching about .33 mm., of which the internal cavity occupies about .15 mm. When torn off and turned edgewise it is seen to be much flattened. The peduncles also are very massive, the longer ones may be attenuated in the middle portion, owing to the perisarc being thinner, but near the extremities they usually reach their normal diameter. The canal gradually widens a little to the base, and as the perisarc is narrowed in at the same part, the area of attachment is slender. Just at the top of the peduncle there is a distinct internal inflation of the canal. The bead-like segment between the hydrotheca and the peduncle may be globular, or it may be angular round the equator, and sometimes there is a second, and larger, globular bead. The peduncles may be tumid at the top and bottom, and their length is variable, some being less than twice the length of a hydrotheca, others ten times that length, but short ones predominate.

The hydrothecae were figured by Von Lendenfeld as obliquely truncate, like those of *H. aggregata* Allman, but the figure is inaccurate, the broader sides being elevated convex lobes. The two lips are not everted. As seen broadside the outer lateral contours are usually, but not always, slightly concave in the middle, and in the longer one there may be a slight angle. Their length varies between .30 and .55 mm., the width from .30 to .45 mm. The gonangium is flattened at the top during its growth, but at maturity the top is smoothly rounded, and firmly chitinous; there is no special border, and only by close inspection can a line be detected at which the convex top ultimately separates. They are about 1.35 —1.60 mm. in length, and .75—.90 in width.

The hydranths, which I have seen only in Von Lendenfeld's specimens, are very characteristic, and quite unlike those of *Orthopyxis*, the body having on one side a large rounded inflation, which is situated just inside the lower lip. In all the hydranths, as preserved, the body was bent over the higher lip, and in close contact with it to the edge; on the opposite side is the lateral inflation, which, when fully expanded, fills in the space above the lower lip; it is sometimes retracted to small dimensions, but more often expanded sufficiently to be a conspicuous feature. Hilgendorf describes a similar lobe in his *Hypanthea asymmetrica*, but mentions that it is divided by a sharp constriction from the body, a character which I have not detected in my specimens. Hartlaub clearly indicates the lateral inflation in his figures of *Eucopella reticulata*.

The base of the hydranth is flattened; one edge of it fits into a notch or sinuation half-way down the inside of the hydrotheca, below the higher lip, the other rests on the lower side, opposite to it.

The distal portion forms a wide infundibuliform expansion or calyx, composed (at least, in regard to its outer layer) of the united proximal portions of the tentacles, and bordered by a thick, annular band, which is attached by its inner margin to the edge of the calyx; outside this circle of attachment the tentacles are free. The annulus is evidently the homologue of the hypostome of *Orthopyxis*, but it is narrower and situated further from the centre, and the fact that it is constant in position in all the hydranths conveys the impression that it has not the mobility of the hypostomes of *Orthopyxis*, which assume all sorts of varied degrees of expansion and contraction. Occasionally in a slide of *Orthopyxis* is seen a hydrotheca, with the tentacles recurved, and the hypostome ex-

panded to its utmost limit, and such a one presents a strong resemblance to the specimens before us. Possibly the treatment to which they have been submitted may have caused them to become fixed in an unusually widely expanded attitude, and may in part account for the characteristic form. I have, however, some specimens of a New Zealand species, in which the condition is similar, and Hartlaub's figure of *Eucopella reticulata* gives a distinct indication of the annular band. An allied species, described by Mulder and Trebilcock as *Eucopella undulata* (Geelong Naturalist, May, 1914), also appears to have the same structure.[1]

Unfortunately, the specimens, probably from the action of a reagent, are excessively dark and opaque, so that I was unable to ascertain the structure satisfactorily, especially the condition of the oral region. In some cases there seemed to be a dome-like elevation in the middle of the calyx, in others it was not apparent. The annulus lies flat, and the tentacles spring horizontally from below it, and are mostly recurved. In one or two cases they were curled inwards over the annulus, which was not at all retracted. As in many Campanularians a biserial arrangement of the tentacles is indicated by their occasional alternate elevation and depression.

The gonothecae are, as Hartlaub says of those of *Eucopella reticulata*, "ham-shaped," rounded at the top when mature, and without distinct operculum. In Von Lendenfeld's specimens some of them contained the gonophores, which were so blackened that their structure could not be made out. One of my Bondi specimens included gonophores in various stages, some of the gonothecae being closely packed with the developing ova. In most cases there were two gonophores. The perisarc of the gonotheca is thicker towards the base, often excessively so. Hartlaub describes the gonotheca of *E. reticulata* as passing into the peduncle gradually, and without distinct constriction or interruption. While none of my specimens quite agree with this, some of them are but slightly contracted at the base; in others, however, the contraction is extremely abrupt. I cannot attach much importance to this character, as the specimens vary greatly in regard to it; moreover, the position in which the gonothecae are viewed has much to do with their apparent form, as they are commonly more or less bent at the base, and decumbent.

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1. In both the species referred to the lateral inflation of the hydranth is evident, as also is the position of the upper portion, that is, leaning over the upper lip of the hydrotheca, and Mulder and Trebilcock say that is the customary attitude during life. In all the species the greatest diameter is across the annular band.

The form from Bondi, figured by me in the Proceedings of the Linnean Society of New South Wales for 1888 (pl. 13, figs. 9-11), corresponds pretty closely with Von Lendenfeld's specimens in size and habit, but differs in the very regularly convex outline of the hydrothecae, recalling, in the shorter ones, Allman's *H. hemispherica*. The base of the gonotheca is mostly broadly rounded, but sometimes narrows more gradually into the peduncle. This form may be provisionally distinguished as var. *rotunda*, but I think it quite probable that the characteristic outline of the hydrothecae may be an inconstant feature; if so, the specimens cannot be dissociated from the type.

The other Bondi form (Proc. Lin. Soc. N.S.W., 1888, pl. 13, figs. 12-15), is of more robust habit, with larger hydrothecae, and stouter peduncles. The hydrorhiza is about as wide as that of the type, but with the internal channel wider. Its lateral branches, most of which are exactly at right angles, are excessively numerous. The hydrothecae may attain the length of about .60 mm., and their lateral contours, as seen in the broader aspect, are somewhat concave, so that the lips appear slightly everted. The internal sinuation, in which the foot of the hydranth rests, is not very deep. The outside is characteristically marked, with irregular raised veins, giving it a woody appearance. It may be distinguished as var. *venosa*.

Eucopella reticulata Hartlaub differs from my specimens mainly in the gonangia, which are attenuated more gradually into the peduncles, and in the size of the hydrothecae, which reach over .75 mm. in length, while those of *S. campanularia* rarely reach .50 mm., and the average is about .40. Hartlaub's discription of the hydrorhiza as wide-meshed scarcely applies to that of the present species.

The forms here described, while agreeing closely with some other species in regard to the trophosome, may readily be distinguished by the gonothecae. Whether the three Australian forms are properly referred to a single species is perhaps questionable, and further investigation must decide; but undoubtedly each of them exhibits occasional resemblances to the others, as in the size and form of the hydrothecae, the presence of veining, and other characters. The thick perisarc of the hydrothecae seems to vary greatly in density, and it is probable that much of the difference between those of var. *rotunda* and var. *venosa* (the two extremes) may be simply due to varying degrees of contraction of the perisarc, caused by the

conditions of growth. And with regard to *E. reticulata*, the characters ascribed to it seem hardly sufficient to justify its specific separation.

Hilgendorf says that the specimens figured by me as *E. campanularia* are *H. bilabiata* (Coughtrey). Of this I am very doubtful. The gonangia of *H. bilabiata*, according to both Coughtrey and Hilgendorf, are very unlike those of the present form. Hilgendorf's account of *H. bilabiata* is not in accord with his figure, especially as regards the peduncles. His specific diagnosis is a copy of Allman's description of *H. aggregata*, including the measurement (¼ inch), but he gives the height afterwards as ½ inch, which agrees with Coughtrey's. The present species does not, I think, reach more than half that height, and I suspect that *H. bilabiata* may be identical with the New Zealand form previously referred to, which has the hydrothecae and hydranths much larger than those of *S. campanularia*, and agrees well with Coughtrey's figure. Neither Coughtrey nor Hilgendorf give any indication of the size of the hydrothecae in their specimens. The former, it is true, says that his figures are magnified fifty times, but there is clearly some mistake, as it is obvious to anyone acquainted with some of the species figured that the magnification is not nearly fifty; in some cases, indeed, it is not twenty.

Silicularia undulata (Mulder and Trebilcock).

Eucopella undulata, Mulder and Trebilcock, Geelong Naturalist (2) vi., 1914, p. 10, pl. ii., figs. 5-7.

This appears to be a different species from *S. campanularia*, being distinguished by the peduncles and the gonothecae. The former are thin-walled and undulated, as in most of the species of *Orthopyxis*, though often becoming thicker and smooth at both extremities. According to the figures the base is not contracted at the junction with the hydrorhiza, as in *S. campanularia*. The gonothecae are decumbent, roughly orbicular in outline, flat beneath, convex above, with faint, transverse rugae, and with a subcircular aperture, looking upward. The hydrothecae are similar to those of *S. campanularia*.

A figure of the hydranth shows it leaning over the higher lip of the hydrotheca, which is stated to be its position when living; the inflation of the opposite side is noticeable, and the oral calyx and the annulus are also shown. As the latter is described as a large cup-shaped proboscis, it would seem that its character is more dis-

tinct than in the mounted specimens of *S. campanularia*. The tentacles are longer than those of that species, a difference also perhaps dependent on the condition of the specimens.

ZYGOPHYLAX RUFA Bale.

Campanularia rufa, Bale, Cat. Aust. Hyd. Zooph., 1884, p. 54, pl. 1, fig. 1; Trans. and Proc. Roy. Soc. Vict., xxiii., 1887, p. 91.

"*Campanularia*" *rufa*, Levinsen, Vidensk. Medd., fra den naturh. Foren, 64, 1913, p. 292.

This species was ranked by Billard as a synonym of *Lictorella antipathes* (Lamarck), but erroneously, as I gather from the same observer's remarks in his report on the British Museum collection, in which he says that *L. antipathes* does not exhibit the slight distal narrowing of the hydrotheca, nor the everted margin, both of which features characterise the present species (as mentioned in the original description). It may also be noted that *L. antipathes* is described as a coarse, woody, and rigid form, reaching according to Lamarck and Allman about four inches, and according to Billard fourteen centimetres, while Ritchie says that some of the specimens of which he obtained portions must have much exceeded these dimensions. *Z. rufa*, so far as it is known, is a small, delicate form, under an inch in height, with the fasciculation limited to a few tubes on the stem only. The original *Lafoëa halecioides* of Allman (1873) seems to resemble *Z. rufa* more than does *L. antipathes*, but it differs in the absence of a perisarcal diaphragm in the hydrotheca. The nearest species to *Z. rufa* would seem to be *Lictorella concinna* Ritchie (Mem. Aust. Mus. iv., p. 823), which is of similar habit, but its hydrothecae differ in form, especially in the much elongated stalk-like condition of the proximal part, which is below the diaphragm.

The pinnae of *Z. rufa* are sub-alternate; between every two on the same side are two hydrothecae, one of them axillary. The apophyses are distinct, and mostly about double the diameter of the hydrotheca at the point of attachment. There is usually no intervening segment, though in exceptional cases such a segment may occur. The portion of the hydrotheca below the diaphragm or "floor" is short, generally about one-sixth of the whole length. In a few cases the apophyses which support the axillary hydrothecae are narrowed down gradually to the diameter of the hydrotheca-base, and not divided from the latter by a distinct joint.

The presence on some of the apophyses of a sarcotheca, or a pair of them, was not mentioned in the original description, having been overlooked by me, an omission which is accounted for by the fact that they are only present in a small proportion of cases, and that they are so small as to be readily passed over, especially as they are mostly below the axillary apophyses, where they are more apt to be obscured. In fact, I could only find three or four on the pinnae. In a few other instances marks were visible where they had been detached, but for the most part even these were wanting. These little calycles are not unlike the hydrothecae in shape, but not narrowed at all towards the end.

THYROSCYPHUS MARGINATUS Bale.

Campanularia marginata, Bale, Cat. Aust. Hydr. Zooph., 1884, p. 54, pl. 1, fig. 2; Proc. Lin. Soc. N.S.W. (2), iii., 1888, p. 758. Bartlett, Geelong Nat., (2) iii., 1907, p. 62, fig. —.

"*Campanularia*" *marginata*, Levinsen, Vidensk. Medd. fra den naturh. Foren, 64, 1913, p. 289.

This species, which on account of its possessing hydrothecae with a four-valved operculum, I now refer to the genus *Thyroscyphus*, is nevertheless of peculiar habit, differing from that of the other known members of the genus. In its simplest form it consists of a single hydrotheca, borne on a peduncle two or three times its own length, which may have, near the base, a few irregularly-placed joints; it therefore differs little in habit from such species as *Orthopyxis caliculata*. But most commonly this structure is repeated two or three times, and in each case the new peduncle is given off laterally from the preceding one, immediately below the summit of the latter, on which the hydrotheca is borne. The distal end of the peduncle is usually a little curved, and the next peduncle springs from the outer side of the curve. The curves do not usually alternate; frequently two or three in succession are directed to the same side. Occasionally two new peduncles spring side by side from the preceding one.

In the original description I mentioned that I had only seen the operculum in a fragmentary condition, and so delicate is its nature that I have not, up to the present, seen a perfect one. However, I have specimens sufficiently well preserved to show that the operculum is of the type which characterises the genus *Thyroscyphus*. In some instances all trace of the operculum had disappeared, although the hydranths still survived.

Levinsen remarks that the sub-marginal band is doubtless due to a regeneration; the fact, however, that it is always present, and is constant in its position, seems in itself sufficient to negative that view. It is, like the marginal band, a thickened ridge surrounding the hydrotheca internally, and it not uncommonly corresponds to a slight external constriction. It varies in the extent to which it is thickened, being sometimes feebly developed, especially in the newly-formed hydrothecae; and in any case, it is somewhat less robust than the border-thickening, at least in the vicinity of the four marginal points. The marginal band is at least as strongly marked at these points as elsewhere, the secondary band does not usually form pronounced points like the marginal one, but is more bluntly rounded at those positions.

The hydrotheca is without a fully-developed diaphragm, but there is an internal perisarcal ring just above the base. Higher up there is a zone of thinly scattered bright points.

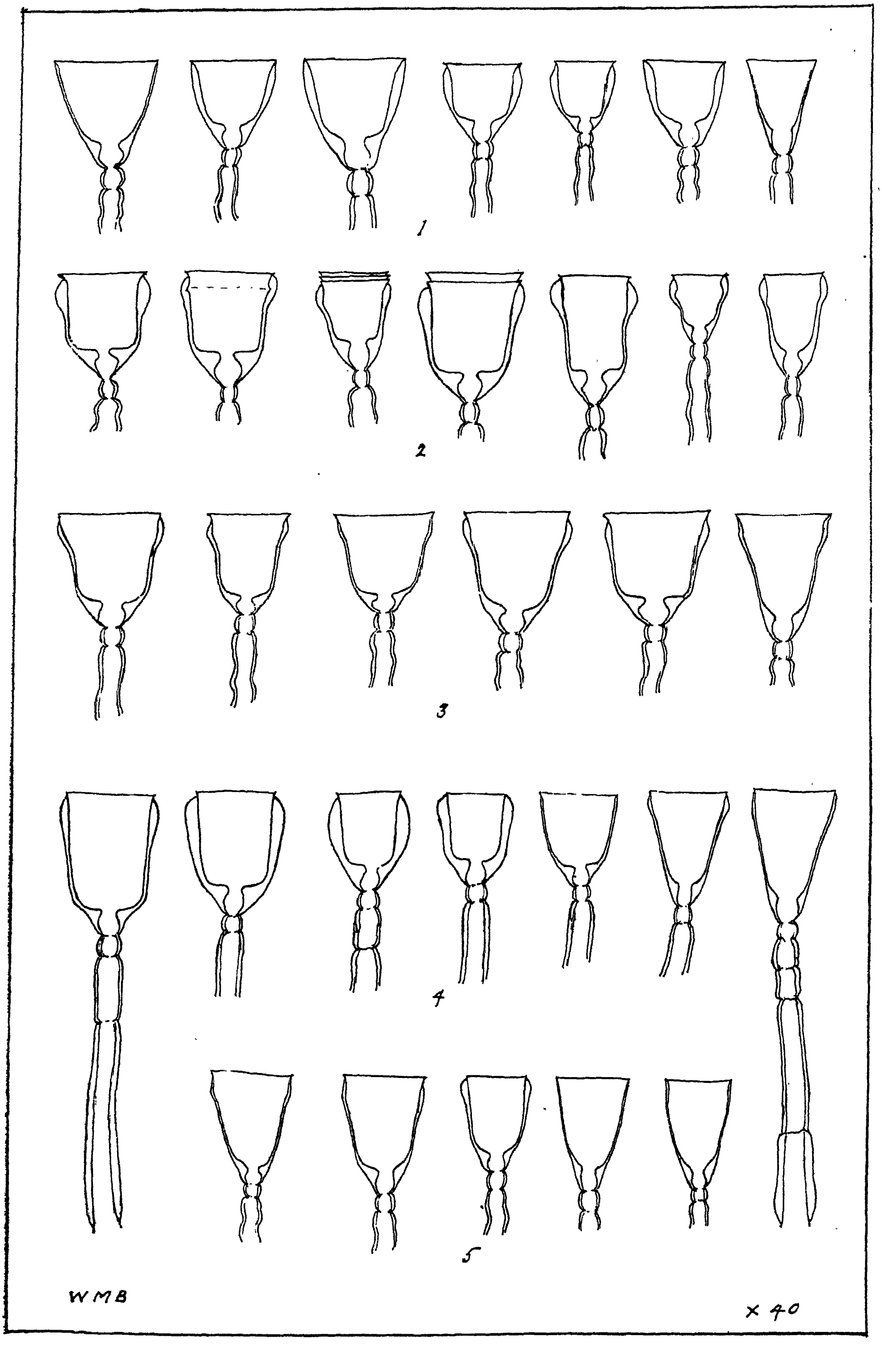
EXPLANATION OF PLATES.

Plate XI.

Fig. 1.—*Orthopyxis caliculata* (Hincks).
Fig. 2.—*Orthopyxis macrogona* (Von Lendenfeld).
Fig. 3.—*Orthopyxis platycarpa*, n. sp.
Fig. 4.—*Orthopyxis angulata*, n. sp.
Fig. 5.—*Orthopyxis Wilsoni*, n. sp.
(All magnified 40 diameters).

Plate XII.

Fig. 1.—*Orthopyxis caliculata* (Hincks).
Fig. 2.—*Orthopyxis macrogona* (Von Lendenfeld).
Fig. 3.—*Orthopyxis platycarpa*, n. sp.
Fig. 4.—*Orthopyxis angulata*, n. sp.
Fig. 5.—*Orthopyxis Wilsoni*, n. sp.
(All magnified 20 diameters).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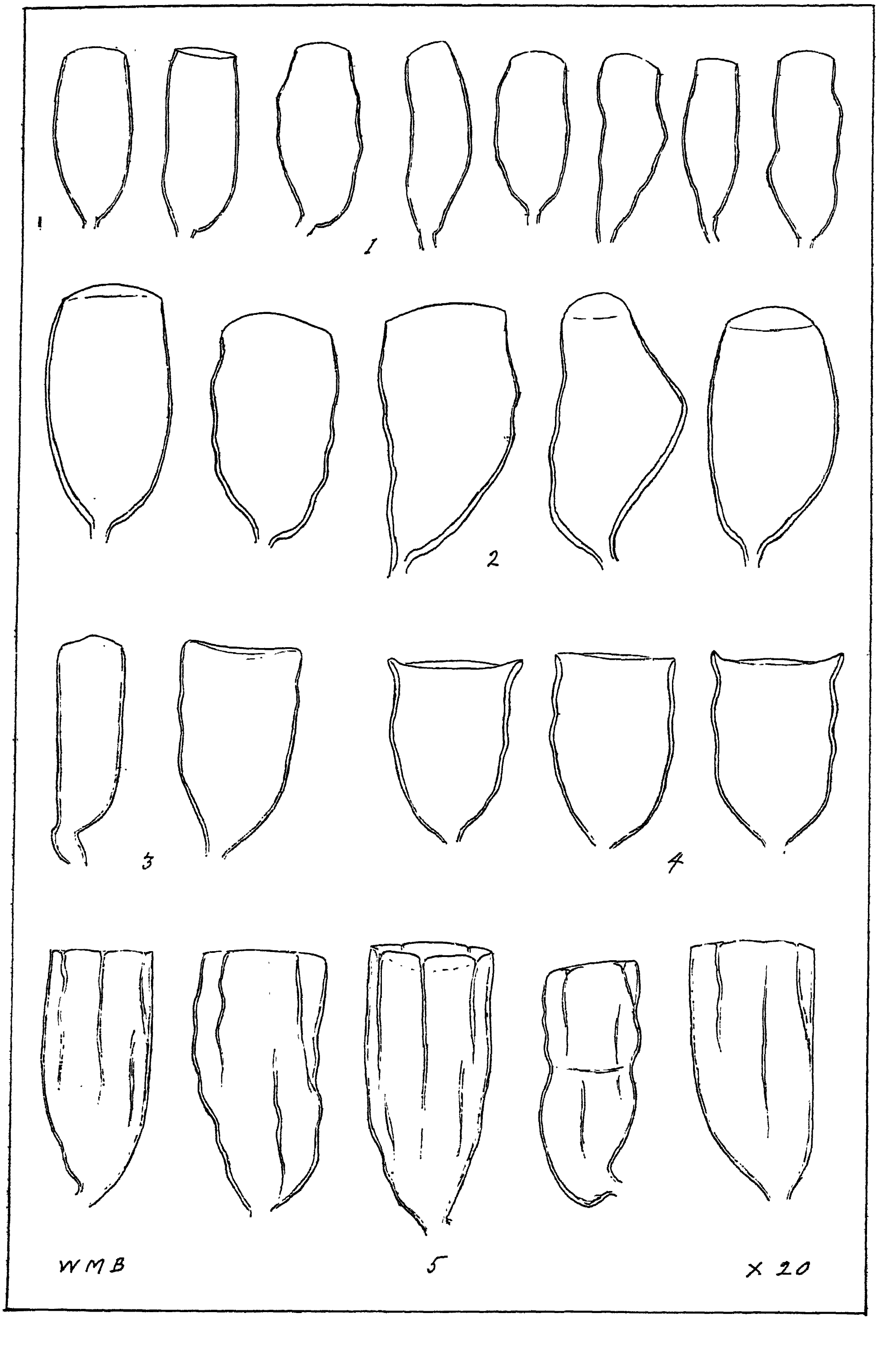
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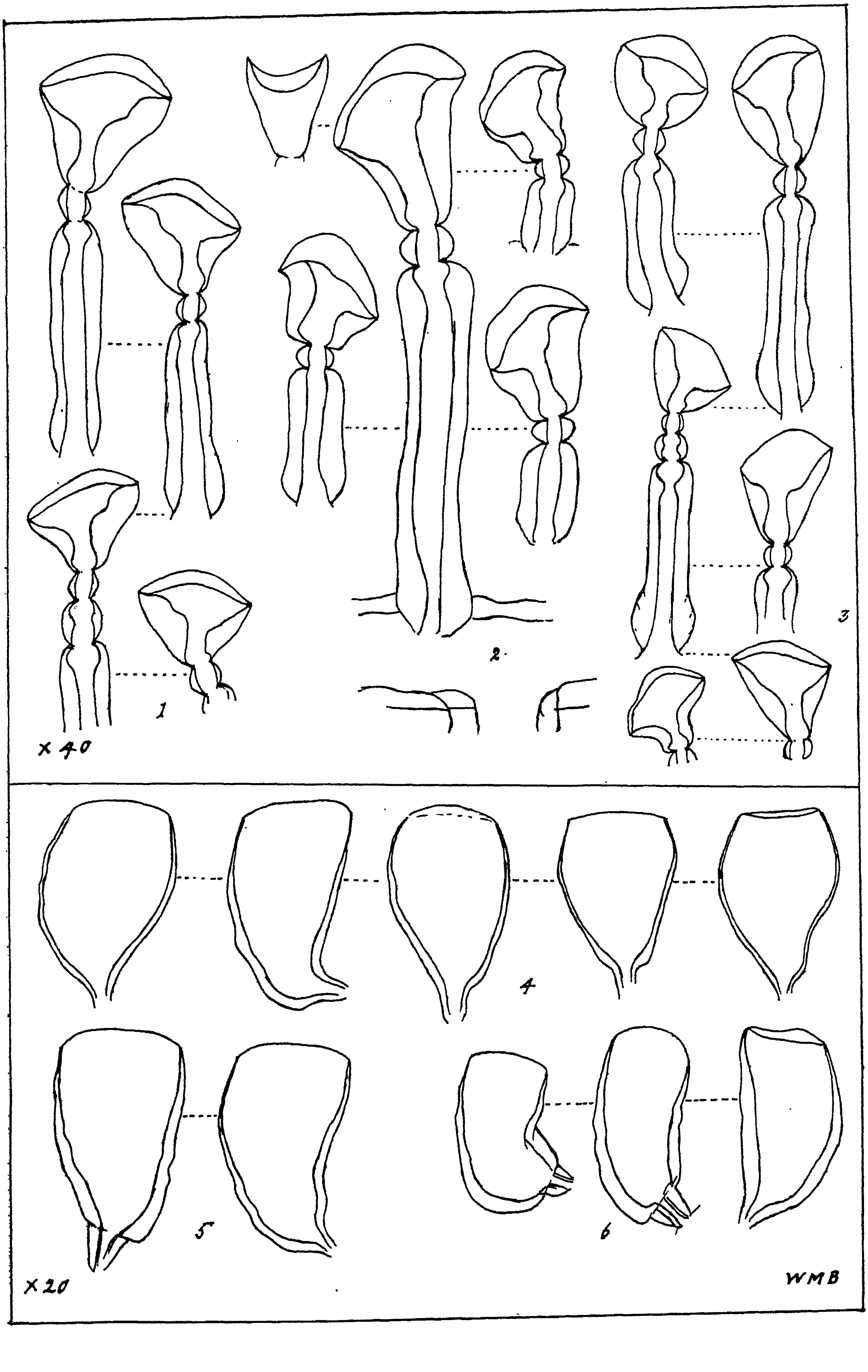
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Plate XIII.

Fig. 1.—*Silicularia campanularia* (Von Lendenfeld), type.

Fig. 2.—*Silicularia campanularia* (Von Lendenfeld), var. *venosa*, n. var.

Fig. 3.—*Silicularia campanularia* (Von Lendenfeld), var. *rotunda*, n. var.

(All magnified 40 diameters).

Fig. 4.—*Silicularia campanularia* (Von Lendenfeld), var. *venosa*, n. var.

Fig. 5.—*Silicularia campanularia* (Von Lendenfeld), type.

Fig. 6.—*Silicularia campanularia* (Von Lendenfeld), var. *rotunda*, n. var.

(All magnified 20 diameters).

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART I., 1914].

ART. VIII.—*On some New Species of Victorian Marine Mollusca.*

BY

J. H. GATLIFF

AND

C. J. GABRIEL.

(With Plates XIV., XV., XVI.).

[Read 9th July, 1914].

This paper contains descriptions of five new species of univalves and two new species of bivalves.

EULIMA VICTORIAE, sp. nov. (Pl. XIV., Fig. 1).

Shell small, thin, rather attenuated, subcylindrical, opaque-white, with a glossy surface. Whorls seven, commencing with a large, blunt, dome-shaped apex; the whorls are flatly convex, and of fairly regular increase. Suture scarcely discernible. Aperture ovate, pointed above. Labrum regularly curved, thin, and very prominent about the centre. The labium resolves itself into a rather broadly reverted lip.

Dimensions of type.—Length, 2.1; breadth, .6 mm.

Locality.—Dredged off Wilson's Promontory.

Observation.—The specific differentiation of this genus is one of the most difficult to study, requiring patient investigation; however, the cylindrical form and dome-shaped apex serve to distinguish the present shell from its Victorian congenors. The nearest approach is perhaps *E. fricata* Hedley from Tasman Sea. Rec. Aust. Mus. vi., 1907, p. 290, pl. lv., fig. 14.

Type in Mr. C. J. Gabriel's collection.

LEIOSTRACA KILCUNDAE, sp. nov. (Pl. XIV.. Figs. 2 and 3).

Shell minute, light-brown colour, smooth, shining, sufficiently transparent to view the axial-pillar. It is tipped with a distinctly rounded dome-shaped apex. Following this are five flatly convex

whorls, parted by a linear suture. The colouration of the whorls is fairly uniform, with no indication of markings as in the previous species. The shell is much rounded anteriorly. Aperture pyriform. Labrum thin, simple. Labium moderately thick on the body.

Dimensions of type.—Length, 1.75; breadth, 6 mm.

Locality.—Kilcunda, in shell sand.

Observation.—This is the smallest of our Victorian species, and is immediately separable by its squat form, dome-shaped apex, and uniform colouration. Its nearest ally is *L. joshuana*, Gatliff and Gabriel, which is here refigured for comparison.

Type in Mr. C. J. Gabriel's collection.

LEIOSTRACA STYLIFORMIS, sp. nov. (Pl. XIV., Figs. 4 and 5).

Shell minute, acuminate, smooth, glassy. Whorls nine, through which the axial pillar may be plainly seen. Whorls are slightly convex; suture fairly distinct in consequence of the slight rounding of the whorls. The generic characteristic is indicated in the later whorls by fairly distinct, but irregular orange-tinted markings, more numerous and more pronounced on the body-whorl. Aperture somewhat pyriform, outer-lip thin and roundly prominent at the periphery. Inner lip slightly reflected.

Dimensions of type.—Length, 2.5; breadth, 8 mm.

Locality.—Dredged off Wilson's Promontory.

Observation.—A most delicate and curious little shell; its distinct acuminate form serving to distinguish from the Victorian members of the genus.

Type in Mr. C. J. Gabriel's collection.

CYCLOSTREMA KILCUNDAE, sp. nov. (Pl. XV., Figs. 8, 9 and 10).

Shell very minute, white, hyaline, of four whorls including the smooth globular protoconch. Discoidal, spire sunken, widely umbilicated. Ornamented with transverse riblets, about twenty-seven on the body-whorl, they are irregularly spaced, becoming more crowded towards the mouth, the intervening spaces are traversed by very fine encircling incised lines. Mouth circular.

Dimensions of type.—Height, .25; diameter, 1 mm.

Locality.—In shell sand, Kilcunda.

Observation.—Type in Mr. J. H. Gatliff's collection.

CYCLOSTREMA VERCOI, sp. nov. (Pl. XV., Figs. 11, 12 and 13).

Shell very minute, white, opaque, of four whorls including the protoconch. Discoidal, widely umbilicated, spire sunken. Whorls crossed by riblets, about seventeen on the last whorl, the intervening spaces are smooth with the exception of a median spiral thread on the base. Mouth circular.

Dimensions of type.—Height, .27; diameter, .75 mm.

Locality.—Dredged off Wilson's Promontory.

Observation.—Type in Mr. J. H. Gatliff's collection.

MYODORA SUBALBIDA, sp. nov. (Pl. XV., Fig. 14).

Shell white, oblong, obliquely truncated posteriorly, rounded anteriorly, concentrically ridged, ridges somewhat rounded, regularly spaced; about fourteen in number. Umbos central, acute. The whole shell is covered by very fine radial striae, under the microscope this sculpture is divided into closely compacted elongate, flattened, hexagonal areas, angularly defined posteriorly, see figures 15 and 16. Right valve convex, with an angle extending from the umbos to the margin, and defining the truncated area. Left valve similar to the right valve, but rather deeper. Pearly inside.

Dimensions of type.—Length antero-posterior, 10.; umbo-ventral, 5.5 mm.

Locality.—Dredged in about seven fathoms, Western Port.

Observation.—Resembling *M. albida,* T. Woods, with which species *M. corrugata,* Verco, is conspecific. Dr. Verco has kindly compared our shell with his type and confirms our opinion that it is distinct from our new species.

Type in Mr. J. H. Gatliff's collection.

DOSINIA VICTORIAE, sp. nov. (Pl. XVI, Figs. 17, 18 and 19).

Shell cream-coloured, rather brittle, inaequilateral, the anterior side being the shorter. Umbods fairly prominent, slightly incurved, and situated at about one-third of the whole length from the anterior. The concentric sculpture resolves itself into about 65 excessively thin erect lamellae, the interstices of which are microscopically striate. The interstices are further sculpturd by fine obsolescent radial riblets which are not seen to ascend the lamellae, and are a little less frequent than the minute striae. Lunular area

of a brownish tinge, elongately-cordiform, medially elevated, and ornamented with imbricating lamellae. The ligament is sunken, narrow, and long. Hinge area normal. The pallial sinus is broad, well defined and obliquely ascending to about the centre of the valve. The surface of the shell has four sub-equally spaced rays of brown, arrow-shaped markings. Further colouration may be seen on the post-dorsal margin in four conspicuous brown maculations.

Dimensions of type.—Length, 36; breadth, 34; sectional of closed valves, 16 mm.

Locality.—Western Port, 5-10 fathoms type taken alive; dredged off Portsea, Port Phillip.

Observation.—Under the name of *D. variegata*, Gray, this species was recorded from Victoria by Pritchard and Gatliff, P.R.S., Vic., xvi. (new series), 1903, p. 133. Careful investigation and much correspondence leads us to the conviction that this is manifestly a wrongful identification; and, further, that the shell is an undescribed species. *D. variegata* is extremely variable; this variability with the figures and remarks by Reeve, Conch., Icon. vi. pl. 6, fig. 33a, and Sowerby Thes. Conch. II., pt. 13, p. 675, No. 72, pl. 144, fig. 83, excusably leading Pritchard and Gatliff to regard the Victorian shell as another of its forms. Close study, however, has revealed characters, sufficiently consistent to warrant our separating it as a distinct species. From *D. variegata*, the shell may be readily distinguished by its flatness (although in this respect showing slight variation), by its more elongated lunule and in the character of the radial sculpture. Another misapplied name is *D. histrio* (Gmel), var., an appellation recognised in South Australia. From typical *D. histrio* it is quite distinct as depicted in the well-executed figures, by Römer. Monograph Dosinia, p. 33, pl. vi. figs. 2, 3.

The "Challenger" Report[1] Lamell. p. 152, records *D. histrio* (Gmel), var. from Cape York, Flinders Passage, and Arafura Sea. E. A. Smith, in his observations, remarking: "This species has received several names from various authors. It is the *Venus australis* of Quoy and Gaimard, the *Artemis variegata* of Reeve, *Artemis lirata* and *lenticularis* of Sowerby, and perhaps the *Artemis scabra* of Philippi. The specimens from station 187 (near Cape York) and Flinders Passage resemble the variety *Artemis lirata*." Reference to Sowerby's figure of *Artemis lirata* Thes. Conch., pl. cxliv., fig. 85, clearly shows that our shell has been misunderstood in S. Australia. *D. deshayesi*, A. Ad., as figured in "Challenger"

Report Lamell. pl. 1, figs. 1—1*e.*, the type of which is in the British Mus. of Nat. Hist., is somewhat similar. We deemed it advisable to have a comparative examination of our new species with it, and forwarded specimens to Mr. G. B. Sowerby, who replied as follows, 8.1.14:—"I examined type of *Dosinia deshayesi;* I can understand some of your small ones passing for the young of it, but is certainly a distinct species; its form is different, and it is flatter; the ligamentary area is much narrower, and the character of the concentric lamellae different. It is also certainly distinct from *D. histrio*, which runs into *variegata.* I think you may safely describe it as a new species." Further confusion has been added to the puzzle since one of us received from a South Australian correspondent a St. Vincent Gulf left valve under the name of *D. brazieri*; the author was not given, and diligent search through literature failed to reveal any description under such name: we conclude, therefore, that *D. brazieri* is manuscript.

A medium-sized specimen has been selected for the type. The series studied, ranging from 8 mm. to 45 mm. (paratype), exhibiting some slight variation in contour. The colour rays in some specimens are very clearly defined, while in others almost absent.

We have here to express our many thanks to Mr. F. Chapman for his excellent illustrations of the species.

Type and paratype in Mr. C. J. Gabriel's collection.

EXPLANATION OF PLATES.

Plate XIV.

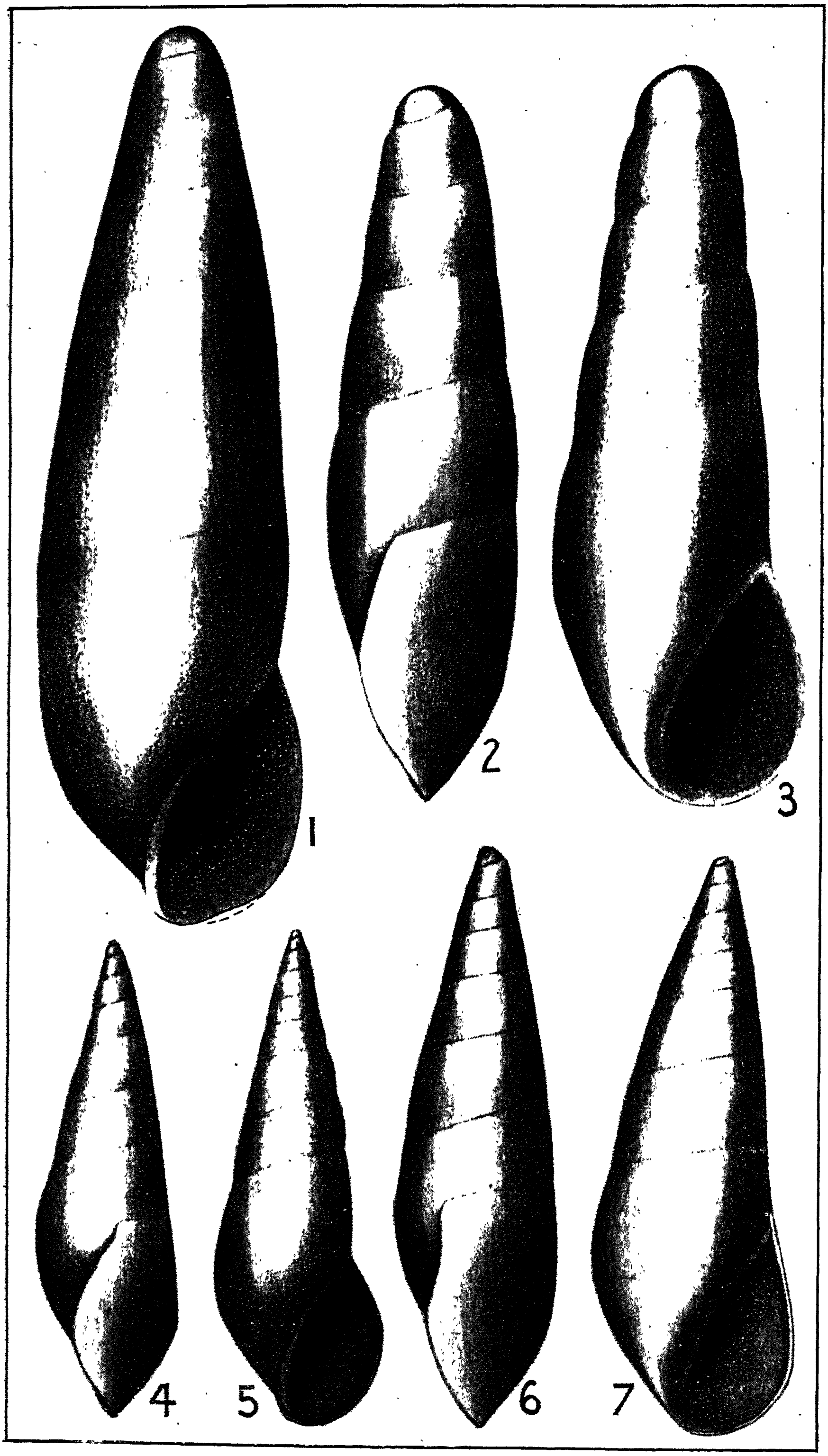
Fig. 1.—Eulima victoriae, sp. nov.
Figs. 2 and 3.—Leiostraca kilcundae, sp. nov.
Figs. 4 and 5.—Leiostraca styliformis, sp. nov.
Figs. 6 and 7.—Leiostraca joshuana, Gatliff and Gabriel.

Plate XV.

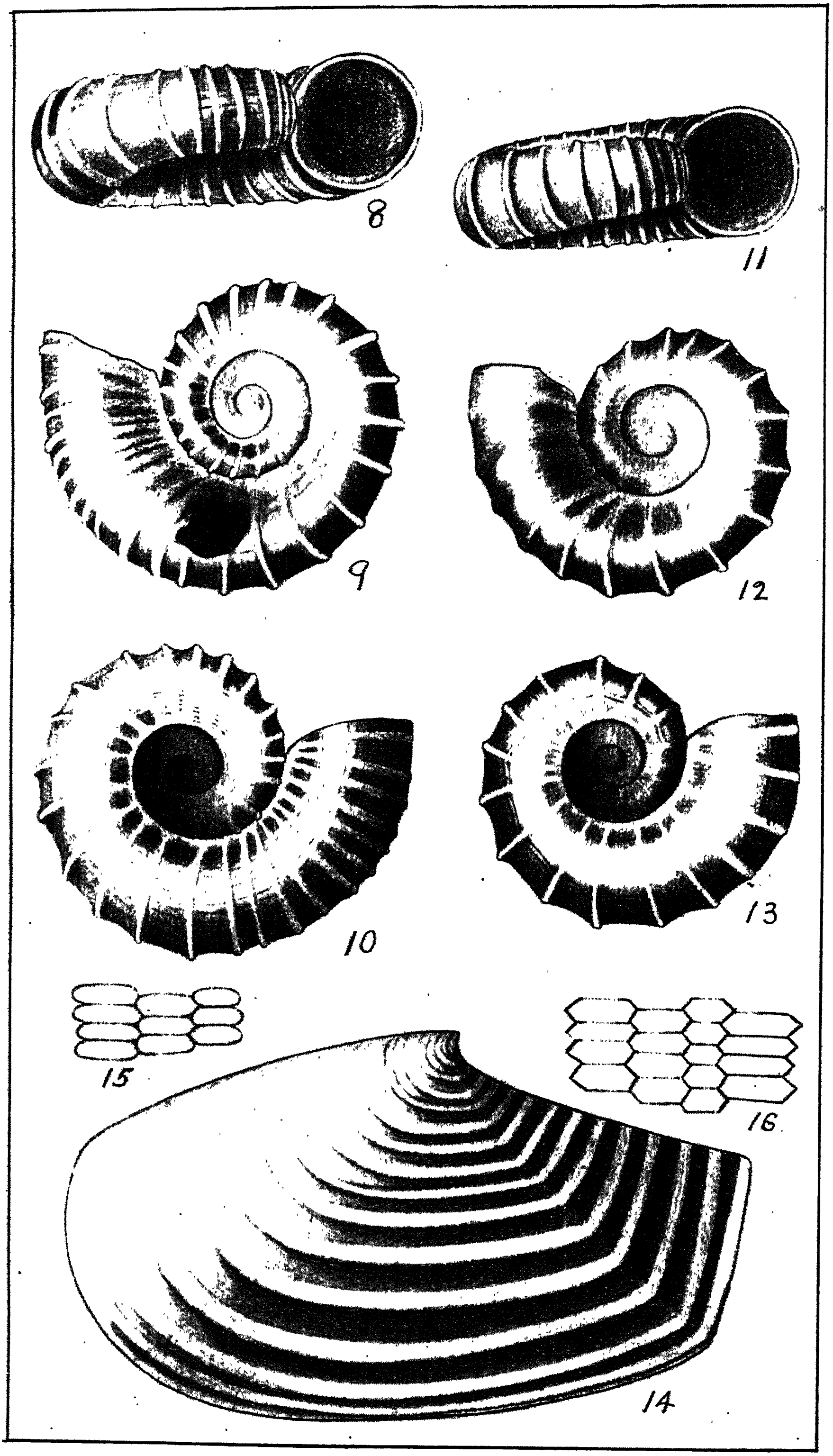
Figs. 8, 9 and 10.—Cyclostrema kilcundae, sp. nov.
Figs. 11, 12 and 13.—Cyclostrema vercoi, sp. nov.
Fig. 14.—Myodora subalbida, sp. nov.
Fig. 15 and 16.—Myodora subalbida, sculpture magnified.
All of the above figures are variously magnified.

Plate XVI.

Figs. 17 and 18.—Dosinia victoriae, sp. nov.
Fig. 19.—Dosinia victoriae, paratype.
Figures natural size.



C.J.G. del.



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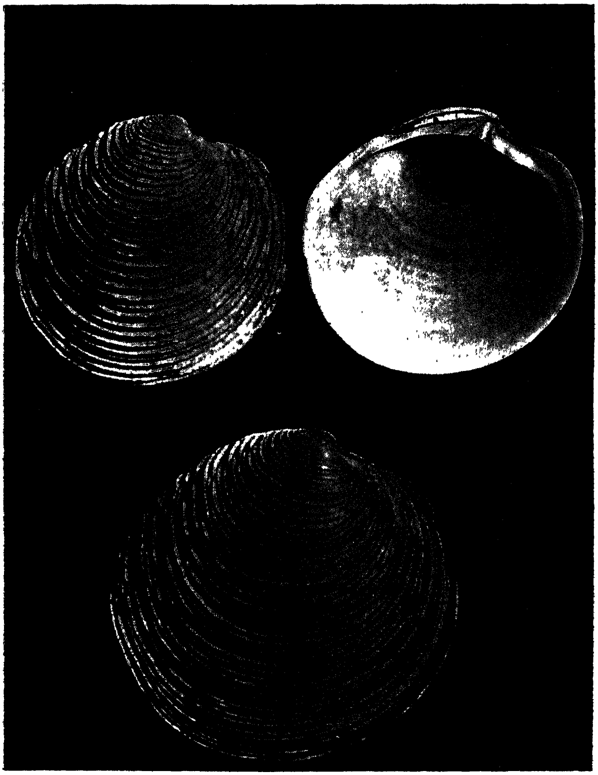


Fig. 17. Fig. 18.

Fig. 19.

F. Chapman, Photo.

[Proc. Roy. Soc. Victoria, 27 (N.S.), Part I., 1914].

Art. IX.—*Additions to the Catalogue of the Marine Shells of Victoria.*

BY

J. H. GATLIFF

AND

C. J. GABRIEL.

[Read July 9th, 1914].

In this paper we have added 21 more species to the catalogue, including two new genera, namely, Cithna and Foramelina, and the total number catalogued now reaches 1052.

We have continued to use the generic names previously adopted, as, although alterations have been made and suggested by various writers, we defer making changes until a pronouncement has been made by recognised authority as to the validity of the alterations.

Argobuccinum retiolum, Hedley.

1914. Argobuccinum retiolum, Hedley. Zool., Commonwealth trawler "Endeavour," vol. ii., part 2, p. 73, pl. 11, f. 5.

Hab.—Trawled in 100-250 fathoms, south from Gabo Island.

Observation.—Size of type: Length, 130; breadth, 60 mm. This species very closely resembles *A. oregonensis*, Redfield, which is found in Alert Bay, British Columbia.

Voluta magnifica, Chemnitz.

1795. Voluta magnifica, Chemnitz. Conch. Cab., vol. xi., p. 8, pl. 174-175, f. 1693-1694.

1840. Voluta magnifica, Chemnitz. Swainson, Malacology, pp. 105 and 317.

1841. Voluta magnifica, Chemnitz. Kuster Conch. Cab., p. 154, pl. 23 and 24.

1844. Voluta magnifica, Chemnitz. Sowerby, Thes. Conch., vol. i., p. 200, pl. 54, f. 103.

1849. Voluta magnifica, Chemnitz. Reeve, Conch. Icon., vol. vi., pl. 1, f. 2.

1853. Cymbiola magnifica, Chemnitz. H. and A. Adams. Genera, vol. i., p 163.
1855. Scapha magnifica, Chemnitz. Gray, Brit. Mus. List, part i., p. 10.
1859.—Voluta (Cymbiola) magnifica, Chemnitz. Chenu. Man. Conch., vol. i., p. 188, f. 959.
1867.—Voluta (Scapha) magnifica, Chemnitz. Angas, P.Z.S., Lon., p. 193.
1871. Voluta (Aulica) magnifica, Chemnitz. Crosse, Jour. de Conch., vol. xix., 3rd series, p. 284.
1872. Voluta (Scapha) magnifica, Chemnitz. Cox, Distribution of Australasian Volutes, p. 8.
1903. Voluta magnifica, Chemnitz. Hedley, Mem. Aust. Mus., vol. iv., p. 371.
1914.—Scaphella magnifica, Chemnitz. Hedley, Zool. Commonwealth trawler "Endeavour," vol. ii., p. 2, p. 72.

Hab.—Trawled in 100-250 fathoms, south from Gabo Island.

MARGINELLA SCHOUTANICA, May.

1912. Marginella schoutanica, May. P.R.S., Tas., p. 45, pl. 2, f. 2.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Observation.—Size of type: Length, 4.; breadth, 2.5 mm. "From *M. pygmaea*, Sowb., it differs in being narrower with the plications reaching much higher on the pillar."

SCALA PLATYPLEURA, Verco.

1906. Scala platypleura, Verco, T.R.S., S.A., vol. xxx., p. 145, pl. 4, f. 6.

Hab.—Western Port.

Observation.—Size of type: Length, 5.; width, 2.3 mm. "It differs from *S. jukesiana*, Forbes, in the more rapid increase of its whorls, its fewer and much more solid varices, which also run forward and downwards instead of backward."

EULIMA VICTORIAE, Gatliff and Gabriel.

1914. Eulima victoriae, Gatliff and Gabriel. Antea page.

Hab.—Dredged off Wilson's Promontory.

LEIOSTRACA KILCUNDAE, Gatliff and Gabriel.

1914. Leiostraca kilcundae, Gatliff and Gabriel. Antea page 94.

Hab.—In shell sand, Kilcunda.

LEIOSTRACA STYLIFORMIS, Gatliff and Gabriel.

1914. Leiostraca styliformis, Gatliff and Gabriel. Antea page 95.

Hab.—Dredged off Wilson's Promontory.

STYLIFER AURICULA, Hedley.

1907. Stilifer auricula, Hedley. P.L.S., N.S.W., vol. xxxii., p. 505, pl. 18, f. 36.

Hab.—Ocean beach, Point Nepean.

Observation.—Size of type: Height, 2.15; breadth, 1.65 mm.

GENUS CITHNA, A. Adams, 1863.

CITHNA ANGULATA, Hedley.

1907. Cithna angulata, Hedley. Rec. Austr. Mus., vol. vi., p. 291, pl. 55, f. 16.

1912. Cithna angulata, Hedley. May, P.R.S., Tas., p. 42.

Hab.—Dredged off Wilson's Promontory.

Observation.—Size of type: Length, 2.9; breadth, 1.85 mm.

CYCLOSTREMA KILCUNDAE, Gatliff and Gabriel.

1914. Cyclostrema kilcundae, Gatliff and Gabriel. Antea page 95.

Hab.—In shell sand, Kilcunda.

CYCLOSTREMA VERCOI, Gatliff and Gabriel.

1914. Cyclostrema vercoi, Gatliff and Gabriel. Antea page 96.

Hab.—Dredged off Wilson's Promontory.

RISSOA PERTRANSLUCIDA, May.

1912. Rissoa pertranslucida. May, P.R.S., Tas., p. 48, pl. 2, f. 8.

Hab.—Kilcunda.

Observation.—Size of type: Length, 2.; breadth, 1.5 mm. A conoid, white, smooth, transparent shell. Our specimens are rather smaller.

RISSOA (AMPHITHALAMUS) ERRATICA, May.

1912. Amphithalamus erratica, May. Id., f. 7.

Hab.—Dredged off Wilson's Promontory.

Observation.—Size of type: Length, 2.; breadth, 1.3 mm. Shell elongately pyramidal, or wedge-shaped, white, glassy, and hyaline.

PHASIANOTROCHUS RUTILUS, A. Adams.

1851. Elenchus rutilus, A. Adams. P.Z.S., Lond., p. 171.

1889. Cantharidus rutilus, A. Adams. Tryon, Man. Conch., vol. xi., p. 136, pl. 34, f. 8.

Hab.—Western Port.

Observation.—This species has been locally united by collectors with *P. irisodontes*, Q. and G., but it is of a broader form. The dimensions of the type are: Height, 17; breadth, 10.5 mm.

EUCHELUS VIXUMBILICATUS, Tate.

1893. Euchelus vix-umbilicatus, Tate. T.R.S., S.A., vol. xvii., pp. 196 and 201, pl. 1, f. 4.

Hab.—Dredged off Phillip Island, Western Port, about 7 fathoms.

Observation.—Size of type: Height, 5.5; basal diameters, 5.5 and 5 mm. "Shell similar to *E. scabriusculus*, but relatively broader, and the whorls more convex."

LUCAPINELLA CRUCIS, Beddome.

1883. Fissurella crucis, Beddome. P.R.S., Tas., for 1882, p. 169.

1890. Glyphis crucis, Beddome. Tryon, Man. Conch., vol. xii., p. 293.

1901. Fissurella (Lucapinella) crucis, Beddome. Tate and May, P.L.S., N.S.W., vol. xxvi., p. 408, f. 11, in text.

Hab.—Portsea, Port Phillip.

Observation.—Size of type: Length, 9; latitude, 5; altitude, 2 mm. Tate and May place this as a synonym of *M. nigrita*, Sowerby, a species that it strongly resembles, but it may be distinguished therefrom by its much finer sculpture, the undulating outline of the outer edge, and it is usually marked by "two red lines on the back forming a cross." We therefore consider it worthy of rank as a species.

M. nigrita, was well known to Mr. Beddome. We have an extensive series from other States, and have no difficulty in separating it from *M. crucis*.

ACANTHOCHITES RUBROSTRATUS, Torr.

1912. Acanthochites rubrostratus, Torr. T.R.S, S.A., vol. xxxvi., p. 169, pl. 7, f. 7, a-f.

Hab.—Dredged 5 fathoms Limeburners Channel, near Sorrento, Port Phillip.

Observation.—Size of type: Dried specimen, length 11; breadth, 6 mm. Our identification has been confirmed by the author; the specimen was obtained on a tunicate; when alive it has a swollen girdle like *A. speciosus*, A. Adams.

CORBULA PIXIDATA, Tate.

1887. Corbula pixidata, Tate. T.R.S., S.A., vol. ix., for 1885-6, p. 177, pl. 17, f. 12a, 12b.

1896. Corbula compressa, Verco. Id., vol. xx., p. 230, pl. 8, f. 2, 2a, 2b.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Observation.—We wrote to Dr. Verco about the validity of his species, and he replied: "I have examined type and co-types of *C. pixidata*, Tate. They are identical with my *C. compressa*, showing slight variations in validity of concentric sculpture, and in transverse diameter."

The type is a fossil obtained "in the Turritella clays at Blanche Point, Aldinga," South Australia.

DOSINIA VICTORIAE, Gatliff and Gabriel.

1914. Dosinia victoriae, Gatliff and Gabriel. Antea page 96.

Hab.—Dredged in Port Phillip and Western Port.

MYODORA SUBALBIDA, Gatliff and Gabriel.

1914. Myodora subalbida, Gatliff and Gabriel. Antea page 96.

Hab.—Dredged in about seven fathoms, Western Port.

GENUS FORAMELINA, Hedley, 1914.

FORAMELINA EXEMPLA, Hedley.

1914.—Foramelina exempla, Hedley Zool., Commonwealth trawler "Endeavour," vol. ii., part 2, p. 71, pl. 11-12, f. 6-8.

Hab.—Trawled in 100-250 fathoms, south from Gabo Island.

Observation.—Size of type: Height, 120; length, 130 mm. A shell somewhat resembling an oyster, with a lateral notch, perforating the right valve at the umbo.

[Proc. Roy. Soc. Victoria, 27 (N.S.), Pt. I., 1914].

Art. X.—*Victorian Graptolites, Part IV.; Some New or Little-Known Species.*

By T. S. HALL, M.A., D.Sc.

(Lecturer in Biology, in the University of Melbourne).

(With Plates XVII. and XVIII).

[Read July 9th, 1914].

The present paper contains the descriptions of some new species, as well as of some that it seems advisable of re-figure. Most of the specimens are from my own collection, others were collected by the officers of the Department of Mines at localities on which I have reported. Two fine specimens are the property of the National Museum, Melbourne, and others were found by Mr. T. S. Hart, at Daylesford.

Didymograptus extensus J. Hall. (Pl XVII. Fig. 1).

For synonymy see S. L. Tornquist, Lunds Univ., Arsskrift, Bd. 37 (1901), Afd. 2, No. 5, p. 14; Elles and Wood, Mon. Brit. Grap. Pt. 1 (1902), p. 8; Ruedemann. Grap. N. York, Pt. 1 (1904), p. 668.

The following description is drawn up from examples from Burn's Reef, Chewton :—

Branches diverging at 180°, so that even from the beginning they are in the same straight line. Width over first theca 0.5 mm.; at 3 cm. 1.5 mm., the increase in width being gradual and continuous. Thecae 10 in 1 cm., inclined at 35° to 40°. Apertural angle 100° to 110°. The gradual increase in the width of the branches, and their lying in one straight line, are very characteristic of this species.

Horizon.—Castlemainian.

Didymograptus perditus, n. sp. (Pl. XVII., Fig. 2).

Branches diverging directly at 180°, somewhat lax, and perhaps somewhat reclined. Width at first theca 1 mm., at 4 cm. 1.3 mm. Thecae 7 or 8 in 1 cm., inclined at about 30°, broadly expanding, so that the denticles are boldly salient. Apertural margin

at 115°. Sicula narrow, curved, 2 mm. long. The branches are given off near its apex, so that its pointed base projects beyond the line of the thecal denticles, giving the hydrosome a very characteristic appearance in this region. The small number of thecae and the salient denticles are also peculiar.

Locality.—Daphne Reef, Lost Gully, Chewton.

Horizon.—Highest zone of Bendigonian.

Didymograptus gracilis Tornquist. (Pl. XVII., Fig. 3).

Tornquist. Acta Univ. Lund. vol. 26, 1890, pt. 2, No. 4, p. 17, pl. 1, figs. 9-12.

Hall, Geol. Mag. 1899, p. 448.

Hydrosome slender, about 1.3 mm. long, and very narrow, with a very delicate virgula, which is traceable for about 0.7 mm. Branches extending at 180°, and apparently arising at very different levels from the sicula, the left side of which projects as an acute tooth. The left branch is given off from about its middle, the right branch appears to arise at the level of the aperture. Dorsal edge of the branch covexly swollen opposite the middle of each theca. Thecae 7 in 1 cm.; slender, outer edge straight and facing somewhat inwards, the two edges forming an acute denticle. Breadth of branch about 0.3 mm.; width of theca at aperture about the same. The virgula, or nema, is visible in some specimens, but not in the specimen figured.

The figured specimen is from Bendigo.

Horizon.—Upper Bendigonian.

Didymograptus aureus n. sp. (Pl. XVII., Fig. 4).

Hydrosome resembling *D. extensus* in form. Branches given off from the sicula at 180°, straight, and scarcely increasing in width. Width at first theca 1.2 mm., at 2 cm. it is 1.5. Thecae 8 in 1 cm. almost straight-sided, inclined at 30°, apertural angle 120°. Sicula 2.2 mm. long, slender, the branches arising near its base. The species differs from *D. extensus* in its more even with, and in the number of thecae in a given length.

Locality.—Bendigo (T.S.H.); Bald Hill, Dromana (D. J. Mahony).

Horizon.—Lower Bendigonian.

DIDYMOGRAPTUS LATENS n. sp. (Pl. XVII., Fig. 5).

Hydrosome small. The branches curve towards one another dorsally, and become horizontal about the region of the fourth theca, the gentle curvature of the dorsal edge of the branch being very characteristic. Sicula broad and stout, about 1.5 mm. long, and slightly more across the aperture. Thecae 10 in 1 cm., very slightly expanding, inclined at 25°, overlapping half their length. Apertural edge normal to the thecal axis.

I have previously referred to this species as *D. aff. decens* Tqt.[1]; but the form of the sicula is different. It differs similarly from *D. suecicus*, Tullb.

Locality.—The type is from Diamond Hill, Bendigo, about 200 yards east of State school.

Horizon.—Upper and Middle Bendigonian. It is common, and apparently always small, at many localities.

DIDYMOGRAPTUS PROCUMBENS n. sp. (Pl. XVII. Figs. 6 and 7).

Branches arising at right angles to the sicula, and then almost imperceptibly reflexed. Breadth at first theca 0.75 mm.; at 1 cm., 1.5 mm.; at 2 cm., 1.75 mm. Sicula 2 mm. long, 0.5 mm. broad, its aperture almost hidden by the first thecae. Thecae narrow, straight-sided, 8 in 1 cm., inclined at about 20° near the sicula, increasing to a little over 30° at 1.5 cm. Apertural margin from 100° to 120°.

In the Bendigo and Lower Castlemaine series the size of the hydrosome never seems to be more than 1 cm. in length, whereas in the slates of Victoria Gully, Castlemaine, just after the disappearance of *Phyllograptus typus*, a form occurs, which I regard as this species, which reaches a length of 4 cm.

Locality of type.—Diamond Hill, Bendigo.

Horizon.—Bendigonian to Middle Castlemainian.

DIDYMOGRAPTUS ADAMANTINUS n. sp. (Pl. XVII., Fig. 8).

Branches about 1.5 cm. long, and rather slender; width about 0.7 mm. near the proximal end, increasing to 1 mm. at about 1 cm. from origin. Branches diverging at 150° to 160°, and almost straight. Thecae 10 or 11 in 1 cm., slightly expanding, overlap-

1. Geol. Mag., 1899.

ping about half their length; inclined at 30°, apertural margin at 100°. Sicula 1.3 mm. long, slender; the first theca arising near its apex.

The species is closely allied to *D. nicholsoni*, Lap., but differs a good deal in the proportions of the proximal part.

Locality.—The type is from Diamond Hill, Bendigo.

Horizon.—Bendigonian.

DIDYMOGRAPTUS MUNDUS n. sp. (Pl. XVII., Fig. 9).

Branches diverging at 130° to 150° from the sicula, and at about the tenth theca, running nearly horizontally, and from two to six cm. in length. Sicula rather narrow, about 1.5 mm. long. Thecae 9 in 1 cm. near the sicula, and about 8 in 1 cm. distally, broadly expanding, overlapping about one-half their length. Apertural margin normal to the thecal axis, inclined at 130°. Outer extremity forming an acute denticle. Width of branch over first theca 1 mm., and at 5 cm. from origin 1.7 mm. Details in sicular region not discernible in any of my specimens.

The species is closely allied to *D. nitidus*, and has generally been referred to it. McCoy, Etheridge and myself have recorded *D. nitidus* from various localities, but I now venture to think incorrectly. I have changed my mind several times about it, but have decided that a new name is advisable. *D. mundus* differs from *D. nitidus* in its slightly larger sicula, in the smaller number of thecae, and in their lower inclination. From *D. euodus* Lap. it differs in its greater width proximally, and smaller width distally, though it agrees with it in several other characters.

Locality.—It is widely distributed, and characteristic of the Upper Bendigonian, and Lower and Middle zones of the Castlemainian.

DIDYMOGRAPTUS DILATANS n. sp. (Pl. XVII., Fig. 10).

Branches 3 or 4 cm. long, rigid, straight, diverging at about 150°, gradually widening. Width over first theca 0.5 mm., and at 25 mm. 1.0 mm. Sicula narrow, length about 1.3 mm. Thecae 8 or 9 in 10 mm., inclined at about 20°, slightly expanding, overlapping one-third to half their length. Aperture normal to axis of branch.

This species has the habit of *D. nicholsoni*, and *D. serratulus*, but differs in the marked increase in width of the branches, and

then different angle of divergence. I have previously recorded it as *D. cf. nicholsoni*. It is associated with *Tetragraptus pendens*, *Goniograptus thureaui*, etc.

Locality.—Daylesford (T. S. Hart, Loc. No. 3, 1908, Type), Bendigo (Min. Dep., Nos. 4191, etc.).

Horizon.—Upper Bendigonian.

DIDYMOGRAPTUS BIFIDUS J. Hall. (Pl. XVII., Fig. 11).

Graptolithus bifidus J. Hall. Grap. Quebec Group, p. 73, pl. 1, fig. 16-18, pl. 3, fig. 9, 10.

Didymograptus bifidus Elles and Wood. Mon. Brit. Grap., 1901, p. 42, pl. 4, f. 1a-1f.

Didymograptus bifidus Ruedemann. Grap. N. York, pt. 1, p. 689.

Branches of hydrosome 10 to 30 mm. long, slightly increasing in width for the greater part of their length. Dorsal margin of branch straight, thecal margin curved. Branches diverging usually at from 20° to 30°, but the angle sometimes greater in a small variety. Thecae 11 or 12 in 1 cm., inclined at from 30° to 50°, four times as long as wide, free for nearly half their length. Apertural margin normal to the axis of the branch, concave, with a slightly mucronate denticle.

The description is drawn up from Victorian specimens. I have previously recorded *D. murchisoni* from Basin Creek, Coimadai, but am of opinion that the single specimen on which the record was founded is *D. bifidus*, and that I have not seen *D. murchisoni*.

Locality.—Wattle Gully, etc., Castlemaine, Basin Creek, Coimadai, Tarilta, Daylesford (T. S. Hart), Steiglitz, Bendigo.

Horizon.—Confined to the lowest zone of the Castlemainian and uppermost zone of the Bendigonian.

DIDYMOGRAPTUS CADUCEUS var. MANUBRIATUS var. nov. (Pl. XVII., Figs. 12, 13).

Differs from the typical form by the immense size of the sicula, which at the point of separation of the branches is as wide as the branch itself. Thecae 10 in 1 cm. Branches diverging at 130° to 140°, and varying from 2 to 3 mm. in width. There is considerable range in the width of the branches, and the angle of divergence, but the great size of the sicula is remarkable. The variety is common at the recorded localities.

Locality.—Quarry in hard blue slate, one mile west of school on road from Woodend to Macedon; in similar rock Steiglitz District (Min. Dept.).

Associates.—*Goniograptus* spp., *Oncograptus upsilon*, *D. caduceus* (large typical variety), *D. forcipiformis*, etc.

Horizon.—Castlemainian.

ONCOGRAPTUS n. gen.

Hydrosome at first biserial, but later dividing into two uniserial branches. Thecae long, narrow and slightly curved.

The form of the genus is quite different from that of any other graptolite. The form of the thecae and the great width of the branches seem to remove it from the Dicranograptidae.

As regards its origin it may be pointed out that it resembles *D. caduceus* in the form of its thecae. Concrescence of the branches of this species for a certain distance would produce a somewhat similar form. The thecae of the uniserial part appear to be opposite, and not alternate, but though I have had a very large number of specimens before me, none show the details of structure very clearly, and I have waited in vain for a long time for better material.

ONCOGRAPTUS UPSILON, n. sp. (Pl. XVII., Fig. 14).

Uniserial portion about 12 mm. long. Breadth at level of bifurcation 10 or 12 mm. Width of uniserial branch about 6 mm. Length of branch 10 mm. These are the dimensions of the type, but the measurements vary a good deal in other specimens. The whole polypary has the form of an arrowhead.

Thecae 9 in 1 cm. Near the proximal end of the hydrosome they are at right angles to the axis, and probably at the proximal end itself have turned through an angle of 90°, and are in a line with the axis of the undivided portion. At the distal end of the uniserial branches they are inclined at about 30°. The apertures are trumpet shaped, and a long recurved denticle is present. The sicula has not been seen. The axil seems united by a membrane.

O. upsilon is the type of the genus.

Locality.—Frederick the Great Mine, Sebastian (Type). Quarries north and west of Gisborne; Steiglitz; Castlemaine (Harris); Yapeen (Ba. 90, Quartersheet 15 N.E.), in National Museum, probably collected by Ulrich in 1864; Ingliston (quarry near 42½ mile viaduct on railway. A. E. Kitson).

Horizon.—Castlemainian, but exact position uncertain.

GONIOGRAPTUS MACER T. S. Hall. (Pl. XVII., Fig. 15).

(Geol Mag., 1899, p. 449, figs. 9, 10).

"Hydrosome slender. Primary branches about 1 mm. in length, and forming an angle of 180° with each other. Secondary branches diverging at about 90° from each other, and then bending in a zig-zag manner at intervals of about 1.5 mm., and giving off tertiary branches from the salient angle. Tertiary branches from two to four in number. After giving off the final tertiary branches the secondary branches, as well as the tertiaries, may reach a length of 30 to 40 mm., and are fairly rigid. Sicula about 1 mm. in length, slender, and very slowly tapering. Thecae 8 or 9 in 10 mm., overlapping by half their length. Apertural margin slightly concave, forming an angle of about 110° with the axis of the branch. Outer margin inclined at about 25° to the axis of the branch, gently curving towards the distal extremity."

Horizon.—Rare in the Upper Bendigonian series, common in the lower zones of the Castlemainian.

There is a fine slab in the collection of the Mining Department (No. 9587), from Bendigo (71 Bo.), which shows about twenty examples of the species. I give a new figure of the type.

GONIOGRAPTUS SPECIOSUS n. sp. (Pl. XVIII., and Text Fig. 1).

Hydrosome, when complete about 35 cm. in diameter, since the distance from the sicular position to the extremity of the final branch given off is 17.5 cm. United length of the primary branches ("funicle") is 3 mm. Length of longest branch measured (a final branch) is 14.5 cm. The number of tertiary branches in the

Thecae × 7.

Fig. 1.

type averages 6 on each side of the four secondary branches, or about 48 in all. Width of branch to tip of denticle 3 mm. Thecae 8 or 9 in 10 mm., inclined at 40° to 50°. Apertural margin at 130°. Thecae slightly curved, and expanded with a somewhat mucronate denticle, and overlapping about one-half their length. The inner end of the outer wall reaches as far back as the denticle of the next theca but one. The type specimen is in the National Museum, Melbourne, and is perhaps the most beautiful graptolite known, though in point of size it is surpassed by a few other species, especially of *Clonograptus*.

Locality.—Slate-quarry about 8 miles S.W. of Woodend. I have a less perfect specimen from the same locality. A fragment of the same species was collected at an unknown locality at Bendigo.

Horizon.—Castlemainian, but exact position uncertain. On the same slab as the type occur *Goniograptus thureaui*, *Didymograptus caduceus*, *D. caduceus var. manubriatus*, *Phyllograptus cf. typus*, *Oncograptus upsilon*, and apparently a *Trigonograptus*, etc.

The type was found by Mr. Neil Johnson, and presented to the National Museum in 1889.

GONIOGRAPTUS CRINITUS n. sp. (Text Figs. 2 and 3).

This species is doubtfully referred to *Goniograptus* as a complete hydrosome is unknown. The specimens found are usually in the form of stout branches, which are bent in a zig-zag, the angular bending being more pronounced towards the proximal end. At times two or three branches are associated, as in the figured specimen. The angles of the zig-zag are from two to four mm. apart, and from the salient angles are given off fine, theca-bearing branches, which are unbranched, and fairly rigid. These may be 100 mm. long or more. The main branches are about 0.75 mm. in diameter, and do not appear to be theca-bearing. The finest branches are about 0.5 mm. in diameter, measured across the aperture of the theca. The thecae are rarely preserved, and when not visible the branch is about 0.25 mm. wide, and about as rigid as a horsehair. The thecae number 11 in 10 mm., and are straight-sided, inclined at about 10°, aperture normal to their length. At first sight this species might be mistaken for a *Thamnograptus*, and I formerly recorded it as such. The ultimate branches are, however, theca-bearing, and are much shorter than those figured by James Hall. *Thamnograptus* does not occur in the Bendigonian or Castlemainian series.

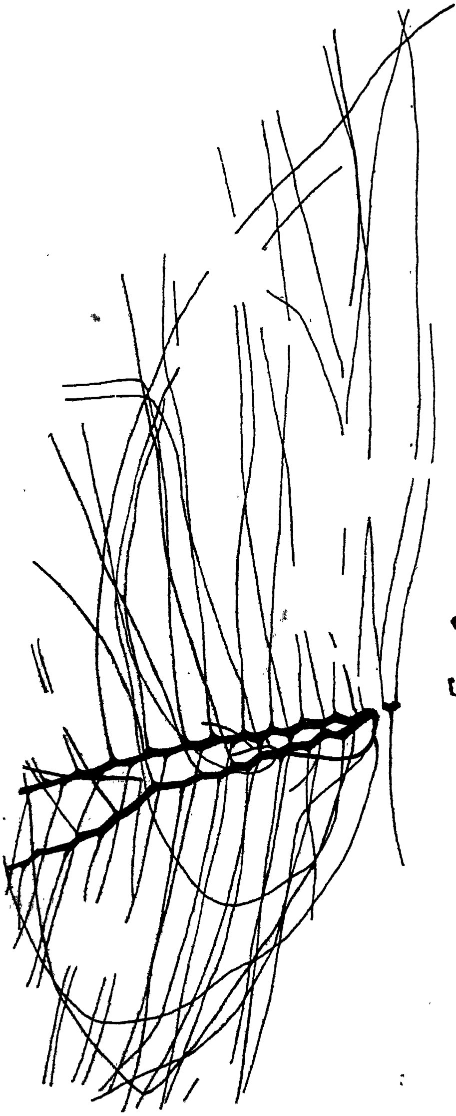


Fig. 2.

Fig. 3

G. crinitus, thecae × 7.

G. crinitus, × 1.

As stated above, I am not sure that the reference to *Goniograptus* is correct, but I hesitate to form a new genus for its reception, till a complete hydrosome is found. The form of the thecae is much more primitive than that of the typical species of *Goniograptus*.

Horizon.—Upper Bendigonian and Lower Castlemainian, but commoner in the former.

GONIOGRAPTUS LAXUS n. sp. (Text Fig. 4).

Hydrosome slender. In the type two branches only are preserved, and these are in the one straight line, and reach a length of 35 mm. Ultimate branches arising at a distance of 2 mm. apart, and may be more than 25 mm. long. No thecae are visible.

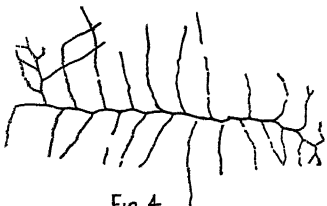


Fig. 4

G. laxus × 1.

The species differs from *G. thureaui* in the more slender and lax habit of the ultimate branches. (Coll. Min. Dept., No. 8360.) The counterpart No. 8358 has been preserved.

Locality of type.—Bendigo (M.D. 38 Bo. Near Garden Gully Mine).

Horizon.—Bendigonian Upper zones.

TETRAGRAPTUS HARTI n. sp. (Text Figs. 5, 6).

Hydrosome slender and rigid, with the habit of *T. quadribrachiatus*. Sicula unknown. Primary branches in same straight line. Secondary branches given off after first theca of primary branch, diverging at about 90°, slender, fairly rigid. Width of secondary branch to tip of denticle at 2 mm. from origin, 0.5 mm.; at 35 mm. it is 1 mm. Thecae 8 in 1 cm., narrow, very slightly expanding, inclined at 15° to axis of branch. Aperture norma to axis of theca. Overlap slightly over one-third.

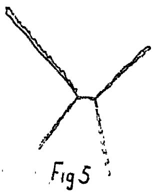


Fig 5

T. harti, type, × 1

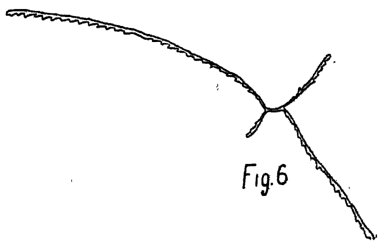


Fig. 6

T. harti, cotype, × 1.

Locality.—Bendigo (M. Dep. 79 Bo., No. 9750, Type); Daylesford, Junction of Jim Crow and Spring Creeks, T. S. Hart; Daylesford, Min. Dep., No. 12,820.

Horizon.—Highest Bendigonian.

TETRAGRAPTUS WHITELAWI n. sp. (Pl. XVII., Fig. 16).

Hydrosome slender. Primary branches at 180°, dividing at the fifth theca. Length of branch, about 4.5 mm. Secondaries diverging at 90°, fairly rigid. Width of branches nearly 0.5 mm. Sicula long and narrow, length 1 mm., breadth 0.2 mm. Thecae 10 in 1 cm., indenting the branch about half its width, inclined at 15°, very slightly expanding. Aperture normal to the axis of the theca.

The great length of the "funicle," slightly over 1 cm., and the slender nature of the branches are well marked characters.

Locality.—Bendigo, Sheepshead Line (79 Bo.), Mining Department, No. 9756 Type. Counterpart, No. 9761. Associated with *T. serra*, (=*T. amii*), *Goniograptus laxus*, *Didymograptus caduceus*.

Horizon.—Upper Bendigonian.

MONOGRAPTUS APLINI n. sp. (Pl. XVII., Fig. 17).

Very minute, curved towards the ventral side. The most complete specimens from an open U-shaped figure. Thecae 18-20 in 10 mm.; apparently coiled in a rounded mass and opening laterally. Sicula about 1 mm. long and narrow.

This is the commonest graptolite in the beds just below the Keilor bridge. The section was discovered by Aplin in 1854, and was the first known graptolite locality in Australia. Unfortunately, the fauna is in a very bad state of preservation, or sixty years would not have elapsed before any species were described from the locality.

M. aplini is closely allied to *M. exiguus*, Nicholson, and *M. nodifer*, Tornquist, but its minute size separates it from them.

Locality.—Keilor, Aplin's section.

Horizon.—Silurian, Melbournian.

MONOGRAPTUS TURRICULATUS Barrande. (Pl. XVII., Figs. 18, 19).

The conical spiral form, and the produced apertural angle of this species are unmistakable. The only two specimens I have seen are on the same slab, and are those figured. The specimens are

in the geological collection of the University of Melbourne, and are in a very imperfect state of preservation.

Horizon.—Silurian, Melbournian.

MONOGRAPTUS PRIODON Bronn. (Pl. XVII., Fig. 20).

Hydrosome straight, rigid, nearly 2.5 mm. wide. Thecae 9 in 10 mm., sigmoidally curved and tapering to the aperture. The distal third bent back to form a strong hook like portion. Overlap about two-thirds.

The description is drawn up from a fragment, the only one I have seen. It is in relief, but merely as a cast. The matrix is a whitish, fine-grained micaceous sandstone.

Locality.—Macclesfield.

Horizon.—Probably Melbournian.

TRIAENOGRAPTUS NEGLECTUS n. g. et n. sp. (Text Fig. 7).

Hydrosome probably circular in outline, and slightly concave near the middle, as in some species of *Dictyonema.* Branches radiating from the centre. These branches give off a pair of lateral branches, one on each side of the main branch. The three branches thus formed produce a trident-like structure, which suggests the generic name. The laterals from one branch usually unite with corresponding laterals given off at the same level by a neighbouring branch, and then run on as a new single branch. This in its turn gives off lateral branches, which behave in the same way. Diameter of the type, 35 cm. Width of branches, 1.5 mm. Interspaces or fenestrae, two or three times as long as wide. Thecae, 5 or 6 in 10 mm., only outer and apertural margins visible. They appear to be straight-sided, and indent the branch for a fifth of its diameter, and appear to be inclined at about 20°, but are so imperfectly shown, that I do not attempt to figure them.

The symmetrical method of branching is peculiar, and unlike that of any other graptolite known to me. Though apparently allied to *Dictyonema*, it seems worthy of generic rank.

The present specimen was found stored away in the National Museum, and the only record of its finding is contained in a newspaper cutting pasted on it. This states that a fossil, presumably the present one, was found in the Paving Company's Quarry, Barker's Creek. This can only refer, I think, to a long-deserted quarry on the right bank of the creek, nearly opposite the late

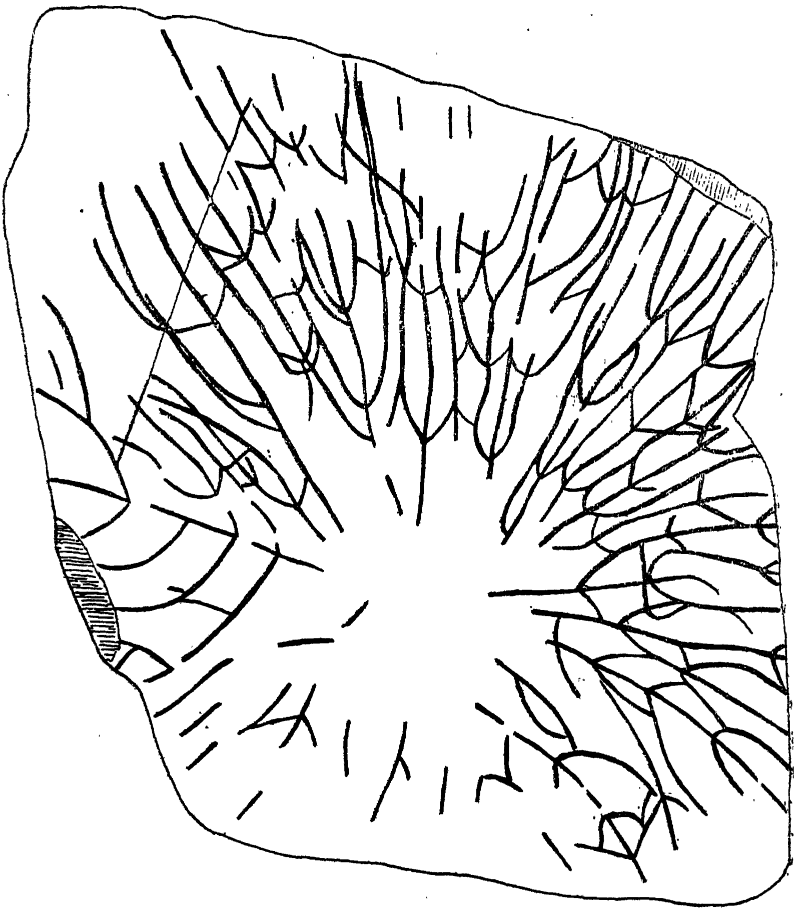


Fig. 7

T. neglectus × ⅓.

Major Ryland's house, and just below the Chinamen's Gardens. In my examination of this quarry many years ago, the only graptolites I found were *Tetragraptus serra*, *Dichograptus octobrachiatus* and *Didymograptus caduceus* (large variety). From the character of the last-named species, I should judge the horizon to be well up in the Castlemaine series, and the geographical posi-

tion of the quarry would support this view. The only other graptolite on the present slab besides *Triaemograptus* is a very indistinct example of apparently *Didymograptus extensus*.

Locality.—Barker's Creek Slate Quarry, North Castlemaine. Mr. W. J. Harris has found a couple of examples in badly cleaved slate from about the middle of the Castlemaine series, and to the south of the town. I have a few fragments, which long puzzled me from similar horizons in the same district, which I am now able to recognise as this species.

Horizon.—Middle and Upper Castlemaine series, but exact position not yet definitely known.

EXPLANATION OF PLATES.

Plate XVII.

Fig. 1.—*Didymograptus extensus* J. Hall. Burn's Reef, Castlemaine.

Fig. 2.—*Didymograptus perditus* n.sp. Daphne Reef, Lost Gully Chewton. (Type.)

Fig. 3.—*Didymograptus gracilis* Tornquist. Bendigo.

Fig. 4.—*Didymograptus aureus* n.sp. Bendigo. (Type.)

Fig. 5.—*Didymograptus latens* n.sp. Diamond Hill, Bendigo. (Type.)

Fig. 6.—*Didymograptus procumbens* n.sp. Diamond Hill, Bendigo. (Type.)

Fig. 7.—*Didymograptus procumbens* n.sp. Diamond Hill, Bendigo. (Co-type.)

Fig. 8.—*Didymograptus admanantinus* n.sp. Diamond Hill, Bendigo. (Type.)

Fig. 9.—*Didymograptus mundus* n.sp. Bendigo. (Type.)

Fig. 10.—*Didymograptus dilatans* n.sp. Daylesford (Sailors' Creek). T. S. Hart. (Type.)

Fig. 11.—*Didymograptus bifidus* J. Hall. Wattle Gully, Castlemaine.

Fig. 12.—*Didymograptus caduceus* var. *manubriatus* var. nov. West of Macedon. (Type.)

Fig. 13.—*Didymograptus caduceus* var. *manubriatus* var. nov. Macpherson's Creek, Steiglitz District. (Co-type.)

Fig. 14.—*Oncograptus upsilon* n. gen. et n.sp. Frederick the Great Mine, Sebastian. (Type.)

Fig. 15.—*Goniograptus macer* T. S. Hall. (Type refigured.)

Fig. 16.—*Tetragraptus whitelawi* n.sp. Bendigo, Sheepshead line. (Type.)

Fig. 17.—*Monograptus aplini* n.sp. Keilor (Aplin's section). (Type.) × 3.

Fig. 18.—*Monograptus turriculatus* Barrande. Keilor (Aplin's section).

Fig. 19.—*Monograptus turriculatus* Barrande. Keilor (Aplin's section).

Fig. 20.—*Monograptus priodon* Bronn. Macclesfield.

(*Note.*—All the figures on this plate are × $1\frac{1}{2}$, except fig. 17, which is × 3.)

Plate XVIII.

Gonigraptus speciosus n.sp. West of Macedon. (Type.) × $\frac{4}{9}$.

LIST OF INSET BLOCKS.

Fig. 1.—Goniograptus speciosus n.sp. Thecae × 7.

Fig. 2.—Goniograptus crinitus n.sp. × 1.

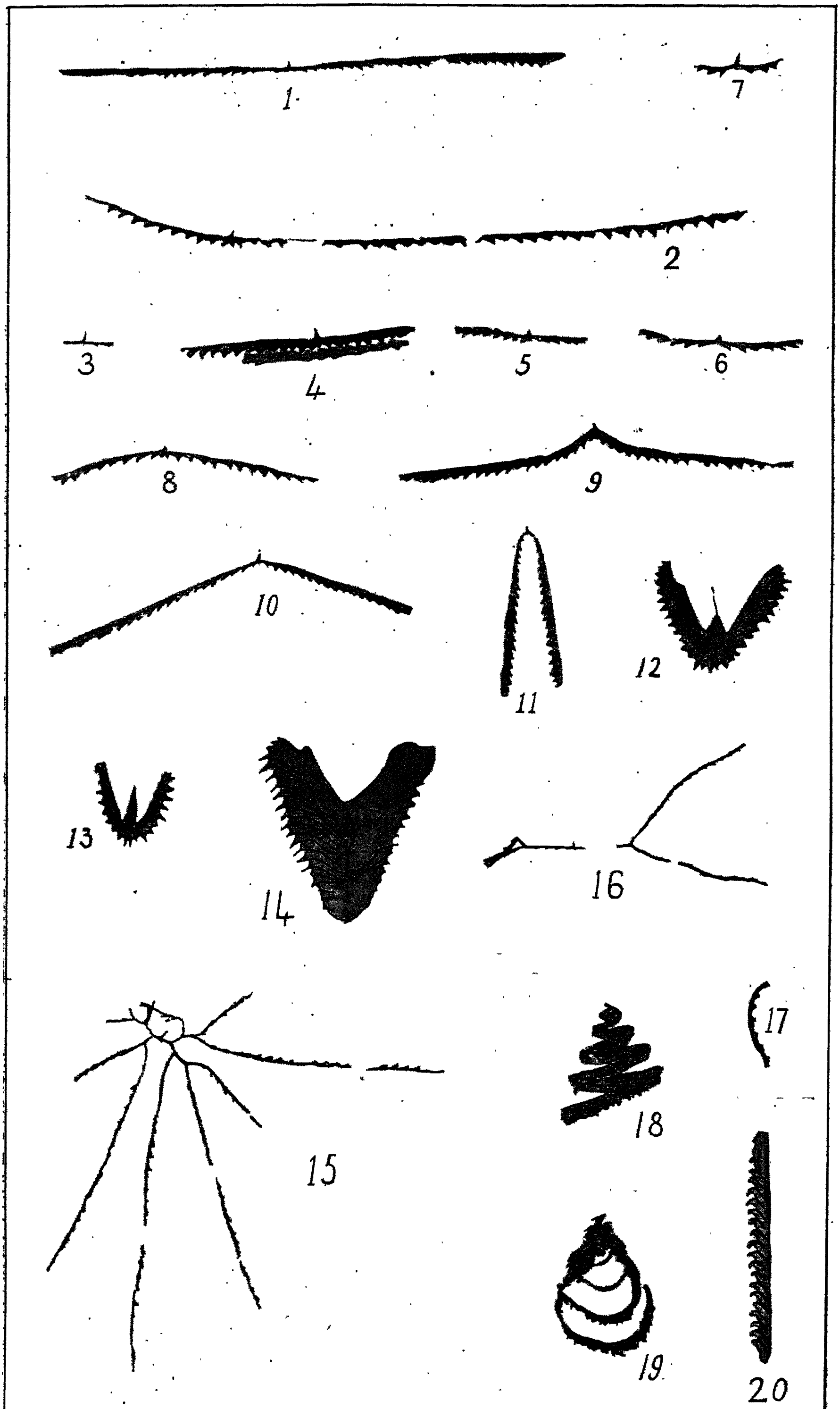
Fig. 3.—Goniograptus crinitus n.sp. Thecae × 7.

Fig. 4.—Goniograptus laxus n.sp. × 1.

Fig. 5.—Tetragraptus harti n.sp. × 1.

Fig. 6.—Tetragraptus harti n.sp. × 1.

Fig. 7.—Triaenograptus neglectus n.gen. et n.sp. × $\frac{1}{3}$. (Traced from a photograph.)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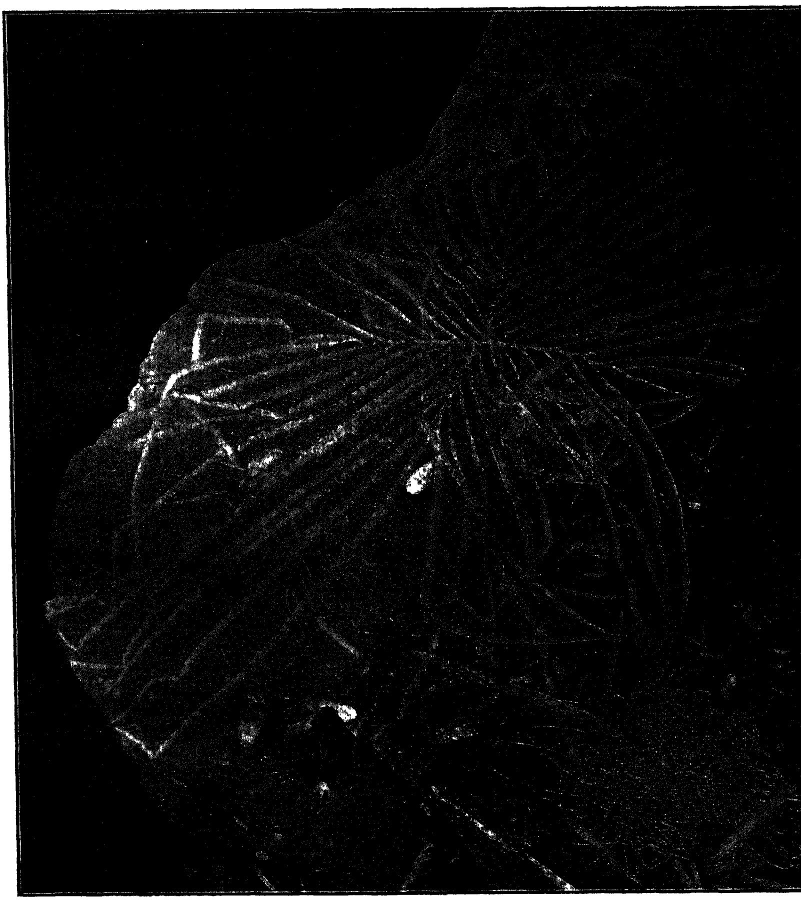

[Proc. Roy. Soc. Victoria, 27 (N.S.), Part I., 1914].

Art XI.—*The Petrology and Mining Geology of the Country near Queenstown.*

By NORMAN R. JUNNER, B.Sc.

(Wyselaskie Scholar in Geology, University of Melbourne, 1913; 1851 Scholar in Geology, Imperial College of Science, London S.W., 1914).

(With Plate XIX).

[Read 9th July, 1914.]

Contents.

1.—Introduction and Previous Literature.

The following contribution is descriptive of certain features in the geology of portion of the Parish of Queenstown. Unfortunately, the field-work was not completed, owing to the transference of the writer to England, and as a result no geological map of the area has been prepared by him. The chief purpose of the paper is to present the results of a study of the chemical and petrological features and metasomatic alteration of an hitherto undescribed intrusion of quartz diorite near Queenstown. Further, attention is drawn to the former richness and future possibilities of an almost forgotten goldfield. Previous references to the geology of this area are scant, and are of no great importance. The following papers

dealing with the area are chiefly concerned with the mining geology, and general mining features, and very little space in them is devoted to purely geological questions.

(1) 1855-56. A. R. C. Selwyn.—"Report on the Geological Structure of the Colony of Victoria, the Basin of the Yarra, etc." Votes and Proc. Leg. Council, Victoria, vol. ii., pt. 1.

(2) 1889. J. Stirling.—"Report on the Mining and Prospecting Operations in the Gippsland and Castlemaine Districts." Appendix H, Quart. Reports of the Mining Surveyors and Registrars of Victoria.

(3) 1894. R. A. F. Murray.—"Report on the Auriferous Country in the Neighbourhood of Queenstown." Prog. Rep. Vict. Geol. Surv., No. viii., pp. 67, 68.

(4) 1894. D. B. Walker.—"Report on Neglected Goldfields." Spec. Rep. Dep. Mines, Victoria.

(5) 1895. J. Stirling & O. A. L. Whitelaw.—"Reports on Rapid Surveys of the Goldfields, Parishes of Warrandyte, Nillumbik, Greensborough, and Queenstown (with Map)." Spec. Rep. Mines Dept., Victoria.

(6) 1899. H. S. Whitelaw.—"Antimony Ores in Victoria." Prog. Rep. Vict. Geol. Surv., No. X.

2.—General Geology.

A.—Silurian Sediments.

These are the northern extension of the same folded series of sandstones, shales, and gritty beds that occur near Warrandyte and Diamond Creek, and with the exception of the igneous rocks near Yow Yow and One Tree Hill, they cover the whole of the area described in this paper. The strike of these beds is consistently east of north, varying from north 10° east to north 50° east. As in the sediments of the country to the south near Warrandyte and Diamond Creek, fossils are relatively scarce, and the only ones found by the present writer were two specimens of Chonetes allied to Chonetes melbournensis, which latter form is restricted to the Melbournian division of the Silurian. These fossils were discovered in black, sandy, occasionally gritty shales from the mullock-tip of a shaft on the Victoria line of reef, One Tree Hill. Selwyn has recorded fossils similar to those occurring in the gritty beds near Warrandyte, from Watson's Creek about six miles north of Warran-

dyte. None of these forms have been described, and therefore they afford no clue to the precise age of these beds. In the absence, therefore, of more detailed palaeontological work in this area, nothing definite can be said at present respecting the age of these sediments.

On stratigraphical grounds, in the assumed absence of major faulting and inversion, the relative stratigraphical position of the beds near Queenstown can be fairly well gauged from sections afforded by two traverses, one along the creek road from Hurst's Bridge to Queenstown, and the other along the road from Kangaroo Grounds through Christmas Hills to Yarra Glen. Considering in detail the first section, the beds near Hurst's Bridge show considerable lithological similarity to those at Diamond Creek, and, further, the Templestowe anticline, which is so marked a feature of Diamond Creek, is seen in a railway cutting immediately south of the Hurst's Bridge railway station. Traversing eastwards from Hurst's Bridge, the strata dip consistently east, at an average angle of about 45°, until about a mile and a quarter beyond Cottle's Bridge,[1] where the Bulleen syncline crosses the road section. This fold, at this point, is not the important feature that it is to the south near Research and the Yarra River.[2] The strata near the axis of the fold are much steeper than they are further south, and soon give place to east-dipping beds with an anticline between. This anticline is the northerly continuation of a fold, not named, but shown on a map accompanying the author's report on the Diamand Creek area.[3] Continuing east, the beds appear to dip east until close to Queenstown township, where a westerly dip is present. It is evident, from this section, that the strata near Queenstown are stratigraphically much superior to the beds of the Templestowe anticline near Hurst's Bridge.

The Warrandyte anticline, devoid of its minor folds, crosses Watson's Creek at a point near to where the creek changes from a N.E.-S.W. course to one nearly east and west. The fold continues in a north-easterly direction to One Tree Hill, where the structure is anticlinal, and the beds are lithologically similar to those of Warrandyte. Sections along the road from Kangaroo Ground to Yarra Glen show that the predominant dip is an easterly

1 Vide, Parish plans of Greensborough and Queenstown for this and other local names occurring in this paper.

2 Vide, J. T. Jutson, "The Structure and General Geology of the Warrandyte Goldfield and adjacent Country." Proc. Roy. Soc. Victoria, vol. xxiii. (n.s.), pt. ii., p. 523, 1910.

3 Proc. Roy. Soc. Victoria, vol. xxv. (n.s.), pt. ii., 1912.

one, after crossing the Warrandyte anticline, and that the strata of this fold are stratigraphically much inferior to the Yeringian beds near Yarra Glen. A general interpretation of the structure, therefore, indicates that the beds near Queenstown are superior to those of the Templestowe anticline, which have been shown by the author in a previous paper to be probably Melbournian or older in age,[1] and to be inferior to the Yeringian strata occuring to the east of this area. Recapitulating, the age of these beds near Queenstown may be regarded tentatively, in the absence of further palaeontological evidence, as either Melbournian or Yeringian; possibly both series are present in the area described.

B.—Quartz Diorite, Yow Yow.

On the spur separating Salter's Gully from Yow Yow Gully, and about one and a-half miles east from Queenstown, a rather tough bluish-coloured, holocrystalline rock, composed chiefly of hornblende and felspar, is seen to outcrop. About the surface, scattered, exfoliated boulders are present in places, but more frequently, and especially near the northern and southern limits of this rock, it is decomposed to a brownish coloured granular mass. The depth of surface decomposition varies, extending in places to over 150 feet.

The intrusion is roughly elliptical in plan and the walls, where examination was possible, appeared to conform approximately in strike and dip with the surrounding strata. On the surface, the sediments in juxtaposition with the intrusion exhibit very little alteraton, and, in fact, the sediments near Queenstown township and Yow Yow Gully away from the intrusion, are much more indurated. According to the District Mining Surveyor,[2] a tunnel driven in 1860 from Salter's Gully, passed through a band of hard altered sandstone, resembling basalt, before reaching the diorite. This points undoubtedly to hornfels, but apparently the occurrence of this rock in proximity to the diorite, is exceptional. In its approximate conformity with the strata, absence of marked contact alteration, petrological and chemical characteristics, and associated auriferous quartz veins, the intrusion is very closely allied to the so-called "dyke bulges" of the Wood's Point district.

Chemical Relations.—A chemical analysis of a typical specimen of the diorite from the Caledonia Mine, Yow Yow, was made by

1 Op. cit. p. 317.
2 Vide, Mining Surveyors' Reports, 1860.

the writer at the Imperial College of Science, London. For purposes of comparison, two very similar analyses of other Victorian diorites are appended.

	I.	II.	III.
SiO_2	52.53	49.65	52.03
Al_2O_3	18.78	16.73	23.57
Fe_2O_3	1.52	0.31	1.60
FeO	6.60	8.99	6.90
MgO	3.02	5.88	5.39
CaO	7.21	7.87	7.80
K_2O	1.73	0.80	1.34
Na_2O	2.54	3.10	2.37
H_2O+	2.24	2.50	1.27
H_2O-	0.53	0.14	0.26
CO_2	0.39	1.08	
P_2O_5	0.32	0.04	
MnO	0.14	0.14	
TiO_2	2.16	2.81	n.dt
S	n.det	n.det.	
(NiCo)O	str. tr.	NiO tr.	
	99.71.	100.04.	99.60.
Sp. Gr.	2.81	2.91	2.855

American Classification.

Magmatic Name	Bandose near Hessose	Hessose	Hessose

I. Quartz Diorite, Caledonia Mine, Queenstown. Analyst, N. R. Junner.

II. Quartz Diorite, Morning Star Dyke, Wood's Point. Analyst, N. R. Junner.

III. Quartz Diorite, Dargo. A. W. Howitt.[1]

The chemical analysis of the Queenstown rock confirms its microscopical determination as a quartz diorite. The marked excess of soda over potash, and the relatively high percentage of lime. finds expression in the predominance of soda lime felspars over potash felspars. The high percentages of water and carbon dioxide are due to the presence of chlorite and calcite, and do not signify that the rock has suffered weathering, as these minerals are regarded as being formed immediately after the consolidation of the rock.

1 Vide, Proc. Roy. Soc. Victoria, 1887.

Further, in weathered rocks, ferric oxide always predominates over ferrous oxide, whilst in the Queenstown rock the reverse is the case.

Petrology.—All specimens examined (some of them from the Caledonia mine coming from greater depths than 200 feet) showed considerable alteration, resulting in the formation of such secondary minerals as chlorite, epidote, sericite, carbonates, leucoxene, pyrrhotite, and iron pyrites. In hand-specimen, the rock is even-grained, and consists of about equal quantities of salic and femic minerals, chiefly hornblende and felspar. Quartz is not visible macroscopically. Microscopically it is a holocrystalline, medium and even-grained rock, consisting essentially of brown hornblende, felspar (both orthoclase and plagioclase), quartz, ilmenite apatite, and the above-mentioned secondary minerals.

The hornblende is the brown variety, which is so characteristic of the igneous rocks of the Walhalla, Wood's Point gold belt. In most sections, little of it remains, as it has been extensively changed to chlorite and epidote. It is usually hypidiomorphic and often includes ilmenite and felspar, showing that it consolidated later than these minerals. Tremolitic outgrowths in optical continuity with the brown hornblende are occasionally present. Twinning, with twin and composition plane parallel to the orthopinacoid, is not uncommon. It is markedly pleochroic, exhibiting the following colour scheme:—

X light yellow brown.
Y fairly dark brown.
Z very dark brown.
and $Z > Y > X$ as usual.

Plagioclase occurs as beautifully zoned crystals, showing the usual albite twinning, and occasionally twinned according to the Carlsbad and Pericline laws. Certain sections of zoned plagioclase show no signs of the albite lamellae, but exhibit basal cleavage, and are therefore cut approximately parallel to 010. One such section gave an extinction angle of $-16°$ from the 001 cleavage for the central core, and $+21°$ from the same cleavage for the clear outer zone, indicating a kernel of labradorite (Ab An), and an outer zone of albite. Almost invariably the refractive index of the clear exterior zone of the felspar is less than that of quartz, proving it to be albite. Symmetrical extinction angles, from the albite lamellae, range as high as 43° for the cores, showing plagioclase near Bytownite. A few phenocrysts of untwinned or simply twinned kaolinised felspar, having a refractive index less than that of

quartz, are orthoclase. Calculating the percentage of felspars from the chemical analysis, according to the American method, we get the following result :—

Orthoclase, 10.01%.
Albite, 21.48%.
Anorthite, 31.69%.

Quartz is interstitial, and occurs in irregular shaped, pellucid grains characterised by fairly abundant fluid inclusions containing bubbles. Ilmenite is farly common, and is present in skeletal and malformed crystals, occasionally showing hexagonal outlines. It is associated frequently with its replacement product, leucoxene, and the triangular parting is often rendered very evident by relict ilmenite bars surrounded by leucoxene. Extraction of any magnetic particles from the powdered rock by a weak bar magnet, showed that only an inappreciable amount of magnetite was present.

The accessory minerals include apatite, and zircon; the latter in chloritic areas is often surrounded by pleochroic haloes.

Of the secondary minerals, chlorite is the most abundant, and is usually intimately associated with hornblende and epidote. It is undoubtedly secondary after hornblende in nearly all cases, and occasionally idiomorphic outlines of the latter mineral are preserved in the chlorite pseudomorphs. The chlorite is of the variety pennine, giving ultra blue polarisation colours. It is decidedly pleochroic X—Y, apple green, Z, yellow, and is microspherulitic in part. Slightly yellow-coloured grains of epidote, referable to pistacite, almost invariably accompany the chlorite derived from the hornblende. Some of the epidote is present as radial aggregates. Fibres of a colourless mineral, having a refractive index between that of chlorite and epidote, and exhibiting very high polarisation colours, are probably calcite. It appears the most of the magnesia, and part of the iron of the original hornblende, have gone to form chlorite, and the lime and the other portion of the iron, with some alumina and water, have yielded epidote. Carbonate occurs generally in massive cleaved, and twinned plates, filling interstices between the quartz and the felspar. It does not occur replacing these minerals or the hornblende to any marked extent. Noteworthy is the fact that it differs very markedly from the metasomatic granular and dusty carbonate so commonly developed in these rocks, as a result of hydrothermal vein alteration. A little sericite replaces plagioclase, especially along cleavage planes. In all sections examined a little sulphide is present, showing marked

preference for areas of ilmenite and undoubtedly replacing the latter mineral in many cases. The sulphide is easily recognised as pyrrhotite by its lighter colour than ordinary pyrites in reflected light, and by its irregular outlines. It is proved without doubt by extracting the magnetic minerals from the powdered rock, and either examining the separated material under a microscope, or by adding a little hydrochloric acid to the separated grains, when sulphuretted hydrogen is readily detected. A very little iron pyrites also accompanied the pyrrhotite thus separated. Pyrrhotite though present in practically all sections, is most common in pegmatitic veins intersecting the diorite.

Acid Dykes in Diorite.—Numerous small aplitic and pegmatitic dykes intersect the diorite. The pegmatites, in general, consist chiefly of large hornblende prisms and colourless felspar, whilst in the aplite dykes, hornblende is rare or absent, and microscopic sections show that orthoclase predominates over plagioclase. Specimen No. 120, Caledonia Mine, is typical of these aplites. The hand specimen of the rock is of a light yellowish colour. Abundant stibnite and pyrites are visible, disseminated throughout the specimen. Microscopically, it is a fairly even-grained, holocrystalline rock, with granitoid texture, and composed of the following minerals:—Quartz, felspar, muscovite, iron and arsenical pyrites, stibnite, carbonate and sericite. No femic minerals are present, and quartz is in slight excess of the total felspar. Orthoclase, generally untwinned and greatly kaolinised, preponderates over plagioclase, which is also much weathered. Sections of plagioclase occasionally show intersecting lamellar twinning according to the albite and pericline laws. Zoning is rare, and in nearly all sections, the mean refractive index of the plagioclase, determined by the Becke method, is less than that of quartz, indicating oligoclase or albite. Maximum extinction angles of 20° from the albite twin planes, prove albite. A few rectangular sections of muscovite with the usual separated leucoxene or rutile, represent, without doubt, hornblende or biotite in the original rock. Most of the mica, however, is of the sericitic type and occurs in the usual aggregates of foils, sometimes arranged radially and often replacing felspar. Veinlets of carbonate and quartz carrying stibnite, traverse the rock. Acicular crystals of stibnite, together with a little ordinary and arsenical pyrites, also occur promiscuously distributed throughout the section. Certain miscroscopic veins of quartz, which intersect plagioclase crystals, are seen to grade insensibly into the

primary quartz grains of the rock, and are therefore also primary.

Comparison of Queenstown Diorite with the Morning Star Diorite, Wood's Point.—The chemical analyses of these rocks show close similarities. From the relative percentage of the alkalies, we should expect a greater proportion of orthoclase in the Queenstown diorite than in the Morning Star rock, and microscopical investigation confirms this belief. The high percentage of water in both analyses is expressed by the relative abundance of chlorite after hornblende. The higher percentages of ferrous oxide and titanium dioxide in the Morning Star rock indicate relatively more hornblende and ilmenite, than in the Queenstown rock.

Mineralogically the rocks closely resemble one another. Especially characteristic is the occurrence of brown hornblende in each of them. Zoned felspars are not usually present in the Morning Star diorite, and epidote is uncommon. Micropegmatite, which is characteristic of the Wood's Point rock, is only present in pegmatitic veins at Queenstown.

C.—Alteration of the Diorite.

Three types of alteration are recognisable.

I. A regional propylitic alteration during, or immediately after, the consolidation of the rock, at relatively high temperature and pressure, resulting in the formation of chlorite, epidote, leucoxene, carbonate, pyrrhotite, and a little sericite.

II. Hydrothermal alteration near the vein walls at much lower temperature and pressure, resulting in extensive sericitisation and carbonation, and in the disappearance of the femic minerals, hornblende, chlorite, and pyrrhotite, and their replacement by muscovite, carbonates, and pyrites.

III. Surface decomposition by present-day vadose solutions. Kaolinisation is referable to the action of these solutions.

I. On most mining fields where ore deposits occur in igneous rocks, a regional propylitic alteration of the country rock can be recognised in addition to the hydrothermal alteration near the veins, but differences of opinion exist as to the cause of this alteration. Propylitisation[1] of the andesites at Tonopah, Nevada, has been ascribed by Spurr[2] to the vein-forming waters filtering through

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1 Propylitisation is here used in the sense defined by Vogt, "Genesis of Ore deposits," 1901, and Lindgren, "Mineral Deposits," p. 446, 1913, and not in the restricted sense of other writers.

2 Geology of the Tonopah Mining District, Nevada, U.S.G.S., P.P., No. 42, 1905.

the rocks. According to Spurr, there are transitions between the propylitic and sericitic facies. According to Kirk,[1] the chloritic and sericitic phases of the alteration of the Butte Granite merge into each other very gradually. Stelzner and Bergeat[2] and Schumacher[3] consider the propylitisation of the Tertiary andesites of Transylvania to be independent of the vein solutions and much earlier, and Finlayson[4] comes to similar conclusions with respect to the alteration of the andesites of the Hauraki goldfield.

The author's study of the auriferous diorites of the Wood's Point gold belt, and also of the related rock from Queenstown, has convinced him that the regional propylitic alteration undergone by these rocks is independent of the vein solutions and that the effects of the latter are superimposed upon the propylitisation. The propylitic alteration is regional, and no relation appears to exist between the amounts of chlorite, epidote and pyrrhotite, and the proximity to a vein fissure. These minerals are just as abundant 20 feet away from the vein fissure as they are two feet away from it. Certainly no transition occurs between the two types of alteration such as Spurr has described at Tonapah.[5] Further, the minerals developed in the propylitic facies are generally characteristic of high temperature deposits. Both chlorite (Pennine) and epidote are common in the crystalline schists, and contact metamorphic ore deposits, which are formed under considerable pressure and at relatively high temperatures. The vein solutions were undoubtedly moderately strong alkaline charbonate and sulphide solutions, and both the above minerals appear to be unstable in the presence of such.

Significance of Pyrrhotite.—Pyrrhotite is usually regarded as a high temperature mineral. Its occurrence as a primary mineral in certain basic rcoks, and its association with such undoubted high temperature minerals as garnet and magnetite in contact metamorphic ore deposits, clearly support this view. At Queenstown, small quantities of pyrrhotite occur distributed through the propylitised diorite. It is closely associated with the ilmenite and leucoxene, and in places occurs disseminated through these minerals. In one section, narrow parallel bars of ilmenite traverse an irre-

1 "Conditions of Mineralisation in the Copper Veins at Butte, Montana." Economic Geology, vol. vii., 1912.

2 "Die Erzlagerstätten." 1905-1906.

3 Zeitschr, f. prakt. Geol., pp. 1-85, 1912.

4 "Problems in the Geology of the Hauraki Goldfields, New Zealand." Economic Geology, vol iv., No. 7, 1909,

5 Op. Cit. p. 210,

gular shaped grain of pyrrhotite, suggesting an intergrowth of the two minerals. However, around the edges of the pyrrhotite, some leucoxene is seen, strongly suggesting that the pyrrhotite is replacing the leucoxene, and that the bars are relics of a former ilmenite grain. The iron, set free from the ilmenite in the change to leucoxene, has apparently united with sulphur from hydrogen sulphide in the gases or solutions, causing propylitisation, and pyrrhotite has formed.

Of late, much attention has been devoted in the laboratory to the study of the iron sulphides, and we are particularly indebted to American chemists for valuable syntheses of them. Of particular interest are the results of Allen, Crenshaw, and Johnston at the Carnegie Institute, Washington.[1] They have artificially prepared pyrrhotite by the direct union of iron and sulphur at 700°, and have shown that pyrite dissociates into pyrrhotite and sulphur in an atmosphere of sulphuretted hydrogen, at temperatures above 565°. The action is represented by the following equation :—

$$FeS_2 \rightleftarrows FeS(S)_n + (1-n)s$$

Pyrite Pyrrhotite Sulphur.

Above 565° the forward action proceeds, and below 565° pyrrhotite, in an atmosphere of hydrogen sulphide, passes into pyrites. The formation of pyrrhotite, and not pyrites in the Queenstown diorite, apparently by the attack of hydrogen sulphide on the ilmenite, should therefore have taken place at high temperature; however, not necessarily as high as 565,° as the dissociation temperature is dependent on the pressure. Pyrrhotite has also been formed synthetically by these authors in an acid environment, at temperatures between 80° and 225,° but the syntheses are undoubtedly inapplicable in our case, since the solutions causing propylitisation must have been alkaline.

Recapitulating, it is seen that the minerals formed during the propylitisation of the diorite, are, in their geological occurrence, usually fairly high temperature minerals. Microscopic and field evidence show that the propylitisation and sericitisation are independent, and that the effects of the latter alteration are superimposed upon those of the former. The chemical analysis of the rock shows, further, that the gases or solutions causing the alteration must have contained water, carbon dioxide, and sulphides. The composition of the original rock does not appear to have been

1 "The Mineral Sulphides of Iron." Amer. Jour. Sci., 4th ser., vol. xxxii., 1911.

greatly changed as a result of the alteration. It appears very likely that the mineralisers had their origin in the cooling magma, and that their escape was made possible by the relief of pressure during the intrusion of the diorite. The gases thus expelled from the magma would permeate the solidifying rock, and cause such alteration as has been described.

II. Hydrothermal alteration adjoining vein fissures. Narrow veins of auriferous quartz, generally only an inch or two in width, but as much as twelve inches wide in places, traverse the diorite. On either side of these veins, the country rock has been bleached for varying distances, generally less than one foot, and rendered much finer grained. Considerable development of pyrite and arsenopyrite together with some stibnite, has taken place in close proximity to the quartz veins. These sulphides are most abundant along the vein wall, and decrease in amount outwards. That the bleaching is a result of the alteration of the diorite by the vein solutions, is certain.

Specimen No. 140, Caledonia Mine, Yow Yow, shows an intermediate stage in the alteration. Macroscopically, it is a fairly even grained rock, greenish in colour, and showing fairly abundant pyrites scattered through it. A section of the rock examined microscopically shows no hornblende or felspar. The hornblende remaining from the propylitic alteration has not been first changed to chlorite, and then to carbonates and muscovite, but apparently it has in part passed directly to carbonate, and in part to a whitish or yellowish, cloudy, nondescript material. Idiomorphic outlines of hornblende are occasionally preserved in this material. The carbonate is dolomitic or ankeritic in character, as dilute hydrochloric acid has very little action on the powdered rock in the cold. Chemical analyses of similar carbonates developed in the diorites near Wood's Point have shown them to be varying compounds of the carbonates of lime, magnesia, ferrous oxide, and manganous oxide. Chlorite still remains in considerable amount, but epidote has disappeared, having apparently succumbed to the action of the carbonate solutions. Local patches of carbonate in the chlorite are closely allied in shape to the epidote grains in the propylitic rock, and undoubtedly replace the latter mineral. Some of the chlorite is beginning to pass to colourless mica (muscovite), and carbonates have been intruded along the cleavage planes, and replace the chlorite in part. The felspars have been almost completely replaced by closely packed sericite flakes. Under high powers,

these areas of sericite are resolved into a mixture of quartz and sericite. Carbonates are notably present in only very small amounts in the altered felspar.[1] The extent to which sericitisation has taken place in the wall rock, is shown by an analysis made for the alkalies. Thus :—Na_2O 0.21%.

K_2O 3.45%.

It will be remembered that in the original rock, soda was in marked excess of potash, and hence it must have been leached out during the alteration whilst the potash was fixed and probably more introduced. It is often assumed that the waters causing such sericitisation were relatively rich in salts of potassum and contained little sodium salts. I see no reason, however, for this assumption,[2] and since the vein solutions have passed through the diorite on their way to the surface they should presumably become richer in soda, and correspondingly weaker in potash, owing to sericitisation, as they approached the surface. Hence, even if the original uncontaminated waters were richer in potash salts than soda salts, the relative proportions of these constituents should soon become reversed. Probably the correct explanation is that under the conditions of temperature, pressure and concentration, existing at the time of the alteration, no stable sodium mineral could form. Paragonite and albite, for instance, are usually high temperature minerals, found in the crystalline schists and contact metamorphic deposits, and are very rarely formed under conditions of hydrothermal vein alteration. The potash mica corresponding to paragonite—namely, sericite, however, has a wide range of existence, occurring extensively in the crystalline schists, and almost invariably in rocks affected by vein solutions, and in the presence of the latter, it appears to be particularly stable. A very little pyrrhotite remains, but iron pyrites has increased considerably in amount. It is scattered through the rock, and shows no preference for regions where chlorite and ilmenite are most common. Quartz has suffered very little change as a result of these alterations. Its peculiar parallel cracks simulating a cleavage, still remain. On close examination under the high power, these cracks are seen to be not regular and straight, but to be occasionally curved and branching. Apatite, in general, is little changed. Occasionally it is fractured and replaced by carbonates. Ilmenite is almost entirely replaced by leucoxene.

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1 Rosenbusch, "Elemente der Gesteinlehre," 1898, pp. 70-71, states that calcite, sericite, and quartz are the products of the attack of carbonated waters on plagioclase felspars.

1 It might be suggested since sericitisation is accompanied by partial dehydration of the rock, that the vein solutions contained very little water ; yet presumably this is not so.

Specimen No. 138, illustrates the extremely altered wall rock near the veins. In hand-specimen, it is a greenish coloured fine-grained rock, greatly impregnated with pyrites, and veined by quartz carrying a little stibnite and carbonate. None of the original minerals of the diorite are recognisable. Microscopically chlorite has entirely disappeared, and is replaced by massive muscovite, giving a biaxial figure and having a fairly wide axial angle. Streaks of carbonate have formed along the cleavage planes. Iron pyrites, arsenical pyrites, and stibnite are all abundant in the altered wall rock. The iron pyrites is often present in irregular shaped grains, and when idiomorphic its form is usually the cube, or a combination of the cube and octahedron, and more rarely, the pyritohedron. Arsenical pyrites is more abundant than the iron pyrites close to the veins, and is readily distingushed from the latter mineral by its silvery lustre in reflected light, and by its idiomorphic outlines. Common forms are combinations of the unit prism and the brachydome, giving wedge-shaped and hexagonal sections. Cruciform twinning, which is so common in the arsenopyrite[1] from the Diamond Creek Dyke, is only rarely seen in the present case. Stibnite occurs singly in prismatic and acicular crystals and as a network of these fibres. When massive, it is silver-grey in reflected light. Some of this material, appearing metallic in reflected light, is deep red in transmitted light.[2] It is most common in the vein quartz, and in the quartz grains adjoining the vein wall. These three sulphides, although independently crystallised, are undoubtedly essentially contemporaneous in origin. Quartz still remains clear, but the grains are embayed, and partly replaced by carbonates. The ilmenite has entirely disappeared, and very little leucoxene remains anywhere in the section. Little pyrites, either the iron variety or the arsenical type, is present in the vein quartz, and the assumption is that the ilmenite and the chlorite have supplied the necessary iron to form the pyrites so abundant in the wall rock.

Summary of the effects of the vein solutions:—In the absence of a chemical analysis of the wall rock, no definite conclusions can be drawn with regard to chemical migrations of the original consti-

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1 In the author's petrological description of the Diamond Creek dyke, arsenopyrite is mentioned as being possibly present. Further examination, however, shows it to be abundant near the vein fissures. Vide, N. R. Junner, Proc. Roy. Soc. Victoria, vol. xxv., p. 339, 1912.

2 Professor Migge was able to prove that stibnite showed straight extinction by examination of very thin flakes of the mineral between crossed nicols in direct sunlight. Vide Neues. Jahrb. Min., vol. i., p. 12, 1898.

tuents of the rock. The microscope, however, reveals the fact that sericite, carbonates, and pyrites are the ultimate products of the original minerals. It is evident that the solutions causing the alteration must have been rich in alkaline carbonates and sulphides. That they also contained arsenic and antimony, is apparent from the abundance of arsenopyrite and stibnite near the veins. The solutions undoubtedly were aqueous, yet the rock has probably suffered dehydration, which is explained by the disappearance of chlorite containing about 13% water, and its replacement by sericite containing only about 4%. A chemical analysis, of the wall rock adjoining a quartz vein in the Morning Star diorite, showed that the percentage of total water was 2.64 in the propylitised rock, and only 0.96 in the sericitised and carbonated facies. The efficacy of moderately strong alkaline carbonate solutions to dissolve rock-forming minerals is well known. Therefore, the extreme metasomatic alteration undergone by the original rock is easily explained as a result of the attack of such solutions. Gold is known to be soluble in alkaline sulphide solutions, and it was probably in such solutions that the gold in the veins at Yow Yow was introduced.

D.—Quartz Porphyry, One Tree Hill.

The eight inch to one mile geological map, published by the Victorian Mines Department, shows an outcrop of porphyrite at Smyth's Gully. The author is not aware of any such rock there, and apparently the rock intended to be shown is the One Tree Hill porphyry. This rock is seen on the surface, at the summit of One Tree Hill, adjoining the Buck line of reef, and is here decomposed to a mass of kaolin containing abundant quartz grains. It can also be seen on the track leading from the hill to the battery in Fern Tree Gully, and a tunnel driven from this gully into the hill to cut the Buck and Swedish reef intersected it. Where seen on the surface, the rock appears to be a dyke,[1] but the relations as revealed by the tunnel section, although not very clear, seem more suggestive of an intrusive pipe. The rock is greatly brecciated in places, and xenoliths of black slate, sandstone, and quartz porphyry are often included in it. Breccia and an agglomerate occur on the surface near the head of Fern Tree Gully, and also in the tunnel, but their relation to the normal igneous rock was not evident. The pebbles of the agglomerate are chiefly quartz porphyry, and are

1 The 1895 geologically coloured parish plan of Queenstown shows a diorite dyke at One Tree Hill.

usually sub-angular in shape, and rarely more than three inches in diameter. In the absence of field evidence to the contrary, it is possible, but not probable, that these supposed volcanic breccias and agglomerates have originated by faulting. The rock is intrusive, and the flow structure, which is characteristic of similar rocks from Lilydale, Steel's Creek, and north of the Black Spur, is absent in this case. Probably the rock fills what was once a volcanic conduit extruding rhyolitic lavas, which are now entirely denuded away. Hand-specimens of the rock are leucocratic and porphyritic, and show phenocrysts of quartz and altered felspar. A little pyrite is also present. Examined microscopically, the rock is seen to have been a quartz-felspar-porphyry, but its pristine characters are now greatly masked by extensive sericitisation, carbonation and occasional secondary silicification.

Section No. 132. The rock consisted originally of large clear panidiomorphic phenocrysts of quartz, fairly large euhedral crystals of felspar, and numerous crystals of a femic mineral, probably biotite, in a microcrystalline ground-mass of the same minerals. Apatite and zircon are accessories. As in the similar rocks described from Diamond Creek, quartz is the only mineral which has withstood the action of the hydrothermal solutions which have caused the alteration, to any marked extent. It is generally clear, and is often rounded and embayed by the ground mass. Such corrosion, however, is probably magmatic, and occurs in many volcanic and intrusive rocks not hydrothermally altered—e.g., Healesville dacites. Isolated inclusions of the ground mass, and numerous glass inclusions containing liquid bubbles, are present in the quartz phenocrysts. Cracks occur about some of these glass inclusions exactly as figured in Idding's "Rock Minerals," fig. 37b, p. 71. Pyramidally terminated crystals of zircon are also seen in the grains of quartz. The felspar phenocrysts have been extensively metasomatically replaced by dusty carbonates and microscopic flakes of sericite, with a little quartz. The alteration of the felspar has been so great in many sections that it can only be recognised by its well-preserved idiomorphic outline. Where the alteration has not been extreme, it can be generally proved without doubt that the felspar is predominantly orthoclase. Numerous included crystals of apatite, zircon, and muscovite occur in the felspar. The original femic mineral was probably biotite. It is now replaced by muscovite, and rutile has separated out,[1] however, not in the form of

[1] Biotite frequently contains a considerable percentage of TiO_2. A biotite from the Dandenong dacite, analysed by H. C. Richards, contained 7·95% TiO_2.

sagenitic webs as in the similar rock from Diamond Creek. Idiomorphic outlines of original felspar are abundant in the ground mass of the rock. They are now replaced by carbonates and sericite, and it is manifestly impossible to tell whether they are orthoclastic or plagioclastic. Abundant granular impellucid carbonate occurs throughout the section replacing both phenocrysts and minerals of the ground mass. The powdered rock effervesces readily when dilute hydrochloric acid is added in the cold, proving that the carbonate is chiefly calcite. Iron pyrites is present in nearly all sections. It is often idiomorphic, consisting of the following forms: —110, 100, and combnations of 100 and 111. The crystals are often surrounded by a rim of secondary quartz arranged radially with respect to the crystal edges. Such quartz may possibly represent recrystallised silica, formed by the attack of sulphuretted hyrogen or alkaline sulphide solutions on the original iron magnesium silicates.

Section No. 135. Brecciated porphyry, One Tree Hill. The felspars in this section are not so greatly altered. Phenocrysts of both orthoclase and plagioclase are present, but the former mineral predominates. It is frequently very greatly sericitised and carbonated, and appears to contain microperthitic intergrowths of albite. One plagioclase phenocryst gave symmetrical extinctions of 20° from the albite twin lamellae, and had a refractive index greater than quartz, indicating felspar near andesine.

Section No. 125. Xenolithic fragments of sandstone are present in places in this section. They show no resorption, and are composed of angular and sub-angular quartz grains, flakes of muscovite, and a little zircon, and brown tourmaline.

Related rocks from the country east of Melbourne.—Acidic dyke rocks (quartz porphyry, felsite, and diorite dykes, of various writers) are fairly common in Victoria, associated with intrusions of granite and granodiorite. East of Melbourne they are fairly numerous, and are known from Diamond Creek, Warrandyte, Templestowe, Frankston, Kinglake, Ringwood, and several other places. Similar rocks near Steel's Creek, Lilydale and Mount Graham are probably the extrusive facies of the same magma. These dykes are usually altered metasomatically, in much the same manner as in the rock described above, from One Tree Hill, and are often traversed by, or associated with, auriferous quartz veins which almost invariably contain stibnite. Auriferous dykes are known at Diamond Creek, Warrandyte, Templestowe, Kinglake,

Scotchman's Creek, near Warburton, and elsewhere. About three miles north of Steel's Creek, an apparently extrusive mass of rhyolite is traversed by quartz veins carrying abundant stibnite, which is auriferous in places.

3.—The Caledonia Gold Field.

A.—History and Production.

Although now abandoned and unknown to most people, the reefs and alluvial of this field have yielded more gold than the better-known Warrandyte reefs. The gold obtained from the Caledonia field has come almost exclusively from the reefs at One Tree Hill, Panton Hills, and Yow Yow, and from the alluvia of the creeks draining these areas. The field was being worked at least as early as 1855, although no official records prior to 1859 are extant. The report of the Mining Surveyor for September, 1859, states that there were 420 miners on this field. In the late fifties and early sixties the One Tree Hill reefs, particularly the Swedish, yielded exceptional returns, but they soon gave place as producers to more consistent reefs like Oram's reef, Panton Hills, and except for occasional very rich yields, later outputs have been unimportant. Oram's reef was a very consistent producer from the time of the discovery in 1859 until about 1885. During this period it averaged three ounces to the ton (a record equalled on very few mining fields), and at the greatest depth reached, the yields were even richer than those from the upper workings. By far the greater part of the gold won from Panton Hills came from this line of reef. Such others as the Napoleon reef, Boomer's reef and Doctor's reef, have yielded only a small quota. The reefs at One Tree Hill and Panton Hills, and also those near Queenstown, are all in close proximity to anticlinal fractures, but those at Yow Yow are of a different type. These reefs occur in the intrusive diorite and in the fractured country rock adjoining the intrusion, and although they have not been so rich as Oram's reef or the Swedish reef, they have nevertheless at various times contributed largely towards the district total. Another important asset to this field was the discovery of coarse gold in the alluvium of certain creeks, particularly in those at Happy Valley, Fern Tree Gully, and Whisky Gully, which have their source in One Tree Hill. These creeks afforded remunerative employment to numerous miners for many years, and some fairly large nuggets (one of them weighing over 100 ozs.) were unearthed.

The alluvial diggings, however, were soon exhausted, and after about the year 1880, this source of gold became unimportant.

Production :—In compiling statistics of gold production, the author has made considerable use of the Quarterly Reports of the Mining Surveyors and Registrars from 1859 to 1891, and of the Annual Reports of the Mines Department from 1891 to 1911. As the latter publication gives only isolated rich yields, and not the complete returns, for the greater part of the above period, any statistics so obtained are necessarily incomplete. The records show that up to 1890, nearly 25,000 ozs. of gold were won from the quartz reefs, distributed thus in round figures :—

Panton Hills	9000 ozs.
One Tree Hill	7500 ozs.
Yow Yow	7500 ozs.

Valued at £4 an ounce; this is equivalent to nearly £100,000 worth of gold. Two thousand ounces is a very conservative estimate for the production between 1890 and 1912, so that the total yield from the field, exclusive of the yield from the alluvial, is well above £100,000. No complete returns of the gold obtained from alluvial sources are possible, as the records are far from being complete.

B.—One Tree Hill.

The productive reefs at One Tree Hill run parallel, and at short distances apart, all outcropping at the top of the hill, within a width of 200 yards. The strike of these reefs varies from N. 15° E. to N. 30° E., corresponding closely to the strike of the contiguous sediments which are here chiefly brown and white sandstones, in places indurated and changed to quartzite. At the south end of the hill one or two small quartz reefs strike across the country rock, but as far as the author is aware very little gold has been obtained from them. The most important reefs worked at One Tree Hill are from east to west, the Buck, Moonlight, Swedish, and the Homeward Bound. Further east than the Buck line are one or two other reefs, the most important of which is the Victoria reef. It was prospected in the late fifties and early sixties, but, according to the records, little gold was obtained. All these reefs dip at fairly steep angles, frequently approaching the vertical, and cut across the strata in depth. In this respect they resemble the reefs at Warrandyte. The Buck line of reef has been extensively developed by means of a tunnel driven from Fern Tree Gully. This tunnel

intersects the porphyry above described, and the Buck reef occurs at the contact of this rock with the Silurian sandstones, and dips very steeply to the west. The reef is here composed of compact milky quartz, slightly mineralised. Pyrites is the dominant sulphide, and stibnite is relatively rare, as compared with its abundance in the reefs at Yow Yow. Native lead has been recorded from the Homeward Bound reef,[1] pointing to the presence of a fairly easily reduced lead mineral. It is interesting to note that native lead has also been recorded from the quartz reefs at Warrandyte,[2] and from the Ringwood antimony mine.[3] According to the Mining Surveyor for the division, the Buck reef was the widest and poorest reef at One Tree Hill. Its average width was about three feet although it was as much as six feet wide in places. The Reports of the Mining Surveyors show that from this reef 2126 ozs. of gold were obtained from 3313 tons of quartz crushed, between the years 1866 and 1873. This practically represents the total yield recorded from the Buck reef, although not the total gold won, as the records are undoubtedly incomplete, and the Reports mention it as being reworked in 1866, after having been abandoned.

The Swedish reef was one of the earliest developed in this field. It is well defined on the surface, and strikes N. 25° E. to N. 30° E., and dips to the south-west, at about 60°. Numerous shafts have been sunk on its outcrop, but practically none of them descend to greater depths than 200 ft., and the majority are less than 100 ft. deep. The Swedish reef gained notoriety in 1859 and 1860, owing to the discovery of some very rich patches of gold near the surface. A few of the earliest recorded yields, undoubtedly from picked specimens, may be quoted to illustrate the extraordinary richness of the quartz, and the nuggety character of the gold.

The early records are far from complete, and, according to the Mining Surveyor, many of the miners were unwilling to divulge the returns. The discrepancy between recorded and actual yields is well illustrated by the Mining Surveyor's Report for January, 1861. He says, speaking of the Swedish reef: "The former owners were about to abandon No. 2 South, on the eve of their finding quartz, yielding, from a few patches, about £8000 worth of gold." At £4 an ounce this gives 2000 ozs. of gold, yet the recorded yield amounted to only 620 ozs. Apart from these very rich patches,

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1 Annual Report, Sec. Mines, Victoria, 1911.

2 Vide, J. Atkinson: A locality list of all the minerals hitherto recorded from Victoria, Proc. Roy. Soc. Victoria, vol. ix. (n.s.), p. 96, 1896.

3 Vide, Mineral Statistics of Victoria, 1877.

Date.		Depth ft.	Quartz. crushed.	Total yield of gold.	Average ozs. per ton.
June,	1859	21	90 lbs.	144 ozs.	3584
August,	1659	21	60 lbs.	240 ozs.*	8960
January,	1860	64	1 bucket of ore	80 ozs.*	—
March,	1860	—	57 lbs.	272 ozs.*	10680
March,	1860	—	specimen	48 ozs.*	—
	1864	—	65 tons	780 ozs.	12
	1865	50	16½ tons	349 ozs.	21.2
	1865	50	.13 tons	134 ozs. 7 dwts.	10.3
	1865	—	2 tons	86 ozs.	43
	1865	—	8 tons	138 ozs.	22.9
	1865	—	10 tons	125 ozs.	12.5

* Recorded in pounds weight, probably pounds avoirdupois, as it was usual in the early mining days to weigh the gold in pounds avoirdupois.

much gold was obtained from the inferior grade quartz, which averaged 4 ozs. to the ton, at 65 ft. The brilliance of the Swedish reef was short-lived, and, after 1870, little more was heard of it.

C.—Panton Hills (Oram's Reef).

As previously mentioned, productive quartz mining at Panton Hills has been almost entirely confined to one line of reef—namely, Oram's. This reef was first opened up during 1859, and it yielded fairly consistently until 1885. After this isolated rich yields were obtained, mostly from the ground previously worked over. The reef outcrops on the east side of the main road from Kangaroo Grounds to Queenstown and Kinglake. It strikes approximately N 25° E., and dips to west. Its width varies from two inches to three feet, and it consists of laminated white quartz, rarely crystalline. Oram's reef has been developed to a depth of nearly 400 ft., and longitudinally for a distance of about half a mile, and has yielded approximately 9000 ozs. of gold; more than 8000 ozs. of which were obtained between the years 1865 and 1885. No gradual change, and certainly no decrease in values, occur in depth, as is evident from the following table compiled from returns recorded in the Mining Surveyor's Reports between 1866 and 1885. Only those returns were used which gave the depth from which the ore was obtained.

Depth fram Surface.	Tonnage Crushed.	Total Yield.	Av. per ton.
0– 59 ft.	$120\frac{1}{2}$	249 ozs. 4 dwts.	2 ozs. 1 dwt.
50–100 „	$231\frac{1}{2}$	564 „ 4 „	2 „ 9 dwts.
100–150 „	$197\frac{1}{2}$	901 „ 5 „	4 „ 11 dwt.
150–200 „	278	1207 „ 4 „	4 „ 7 „
200–250 „	$358\frac{1}{2}$	864 „ 12 „	2 „ 8 „
250–300 „	$674\frac{1}{2}$	2369 „ 17 „	3 „ 10 „
300–370 „	—	—	5 ozs.

These returns show that the richest ore was obtained from between 100 and 200 ft., and that the ore from shallow depths was poorer in value than that from the deeper workings. No inferences can be drawn with safety from these yields, respecting the effect of secondary enrichment on the auriferous quartz. The ground water level occurs at a depth of about 200 ft., and the richest quartz came, therefore, from above this level; although the 300 ft. level alone yielded 2000 ozs. of gold, equivalent to nearly one-fourth of the total gold won from this reef.

D.—Yow Yow.

Several quartz veins have been prospected, with varying success, near the Yow Yow diorite intrusion. The best known of these reefs are Allen's, Eureka, Comet, Murray's, No. 5, and Hirt's reefs. The records show that Allen's reef was the largest producer of these, but, owing to the multipilicity of names of claims and reefs, it is manifestly impossible to calculate the yields from individual reefs with any degree of exactness. Allen's reef varied in width from two to three inches, up to the corresponding number of feet, and was not worked at greater depths than 200 ft. The reef occurs within the diorite, and according to the Mining Surveyor, the yields from the hard, undecomposed rock were just as rich, or even richer, than those from near the surface. With the exception of the Caledonia, none of these reefs have been worked below 200 ft. At this mine a shaft has been sunk between 200 and 300 ft. in depth, and several very thin, nearly vertical dipping, veins, have been worked. These, however, were unprofitable in depth, not because of any decrease in values, but owing to the great amount of very resistant diorite which had to be extracted with the quartz. Stibnite is the predominant vein sulphide, and pyrites and mis-

pickel are sometimes present. Massive stibnite occurs in several of these reefs, especially those situated on the west and north-west sides of the diorite. Calcite is a fairly common gangue mineral. The gold is of a high degree of fineness, as is usual elsewhere in Victoria, where stibnite is the predominate vein sulphide, and is generally valued at more than £4 an ounce. Nearly all these reefs strike between north and north-east, and dip at steep angles. An approximate estimate of the gold recorded from Yow Yow may be stated as 8000 ozs., of which total, more than one-third (about 2700 ozs.) has been recorded from Allen's reef. The Eureka was also an important contributor, and over 1500 ozs. were won from this line of reef. Certain of these auriferous veins, worked within the diorite, pass out into the sediments, and have been found to be payably auriferous for some distance from the intrusion.

E.—Alluvial.

The bulk of the alluvial gold from this field came from the creeks draining One Tree Hill; and, compared with the gold obtained from them, other returns are unimportant. The gold was almost invariably of the nuggety type, and one nugget of 103½ ozs. was unearthed in Cobbler's Gully. The occurrence is of interest, since elsewhere in Victoria large nuggets are generally associated with Ordovician strata, and nuggets of over 100 ozs. have been recorded in only two other areas—namely, Alexandra, and Wood's Point,[1] where undoubted silurian sediments are the country rock. The following is a list, probably not complete, of nuggets recorded from the alluvial near One Tree Hill :—

A.—Cobbler's Gully, or Happy Valley.

Weight.	Depth from surface.	Reference.	Remarks.
103½ ozs.	6 feet.	Q.R.M.S. Dec. 1874[2]	100 ozs. 12 dwts. fine
88 ,,	—	,, Sept. 1860	
84 ,,	Shallow	,, Oct. 1860	78 ozs. fine.
83 ,, 6 dwts.	6 inches	,, Mar. 1870[3]	
72 ,,	—	,, Oct. 1860	Several small nuggets
42 ,,	—	,, Nov. 1860	

1 Vide list of nuggets found in Victoria. Mem. Geo. Surv., Victoria, No. 12, 1912.
2 Quarterly Reports of the Mining Surveyors and Registrars of Victoria.
3 Mixed with quartz. Found in the alluvial of the Swedish reef, 50ozs. fine.

Weight.	Depth from surface.	Reference.	Remarks.
40 ,,	—	,, Sept. 1860	
32 ,, 12 grs.[1]	—	,, Aug. 1860	
28 ,, 11 dwts.	6 feet	Prog. Rep. No. 3, 1875	Estimated 17 ozs. 12 dwts.
17 ,, 12 ,,[2]	12 ,,	Q.R.M.S. Dec. 1874	
11 ,,	15 ,, 6 in.	,, May 1860	
5 ,, 17 ,,	12 ,,	,, Dec. 1874	

B.—Fern Tree Gully.

Weight.	Depth.	Reference.	Remarks.
56 ozs.		Q.R.M.S. Dec. 1880	In two nuggets.
32 ,, ?		,, Mar. 1862	
24 ,,		,, Jan. 1862	
20 ,,		R. B. Smyth, Gold Fields of Victoria, 1868	
10 ,,		M.S.R.[4] Feb. 1861	
10 ,,		,, Jan. 1861	
8 ,,		,, Jan. 1861	
8 ,,		,, Jan. 1861	

C.—Whiskey Gully.

Weight.	Depth.	Reference.	Remarks.
34 ozs. 13 dwts.	11 feet	Q.R.M.S. June 1869	
9 ,,		,, Sept. 1861	
3[3] ,, 5 dwts.	,,	,, June 1869	

According to the district Mining Surveyor, other large nuggets were found and not reported by the finders. The evidence is absolutely convincing that these nuggets have been shed from the reefs, and that they have not grown in situ. Firstly, it is a well-known fact on this field that the richest alluvial has always been found in close proximity to fairly rich reefs—e.g., One Tree Hill. Further in Cobbler's Gully, nuggets have been found in all posi-

1 Recorded from Fern Tree Gully or Happy Valley.

2 Possibly identical with the preceding nugget.

3 Probably Fern Tree Gully, as all nuggets from Cobbler's Gully were obtained at shallow depths.

4 Mining Surveyor's Reports.

tions, from well down the gully right up to the outcrop of the reefs on One Tree Hill. The district Mining Surveyor in 1870 reports the finding of a rich specimen of quartz (83 ozs. 6 dwts. gross weight, 50 ozs. fine) six inches below the surface reef, and undoutedly derived from this reef. The nuggets found nearest the reefs are generally mixtures of quartz, limonite and gold, and show little signs of rounding. Cobbler's gully has yielded the largest nuggets, and there is every reason to believe that they have been derived from the Swedish reef, which has been shown to be a nuggety reef, and much of the gold obtained from it would be best described as nuggets. For instance, a specimen of quartz from this reef, having a maximum dimension of 3 inches, was found to yield 48 ounces of gold.[1] Mr. Hirt, who has had a very intimate acquaintance with this field, told the writer in private conversation that a nugget 40 ozs. in weight, and associated with quartz and limonite, was got from a depth of nearly 100 feet in a claim on the Homeward Bound line of reef. It will be agreed, I think, that the evidence allows of no other conclusion than that the nuggets have been derived by the breaking down by denudation of the former upward extension of such reefs, as the Swedish at One Tree Hill.

F.—Future possibilities, Secondary enrichment, etc.

Oram's is the only reef on this field developed at greater depths than 300 feet, and the majority of the workings have not penetrated below the ground water level. Notwithstanding the shallowness of the workings, there is apparently nothing to show that the values have not been maintained in depth, as is seen from the figures given above for Oram's reef. Of the geological factors that may have influenced the values near the surface, secondary enrichment is the most important. The recognition of its effect on auriferous quartz veins, is frequently difficult, and this is especially so in Victoria. Victorian gold is generally of a high degree of fineness, and usually free from sulphides of the base metals which are easily leached, and either oxidised or redeposited at lower levels as secondary sulphides. Further, most of these mines were developed before secondary enrichment was studied, and practically no facts relevant to the question are now obtainable from the records. The yields from various depths aid us little, as is seen from the tabulated

1 Vide, supra, p. 36.

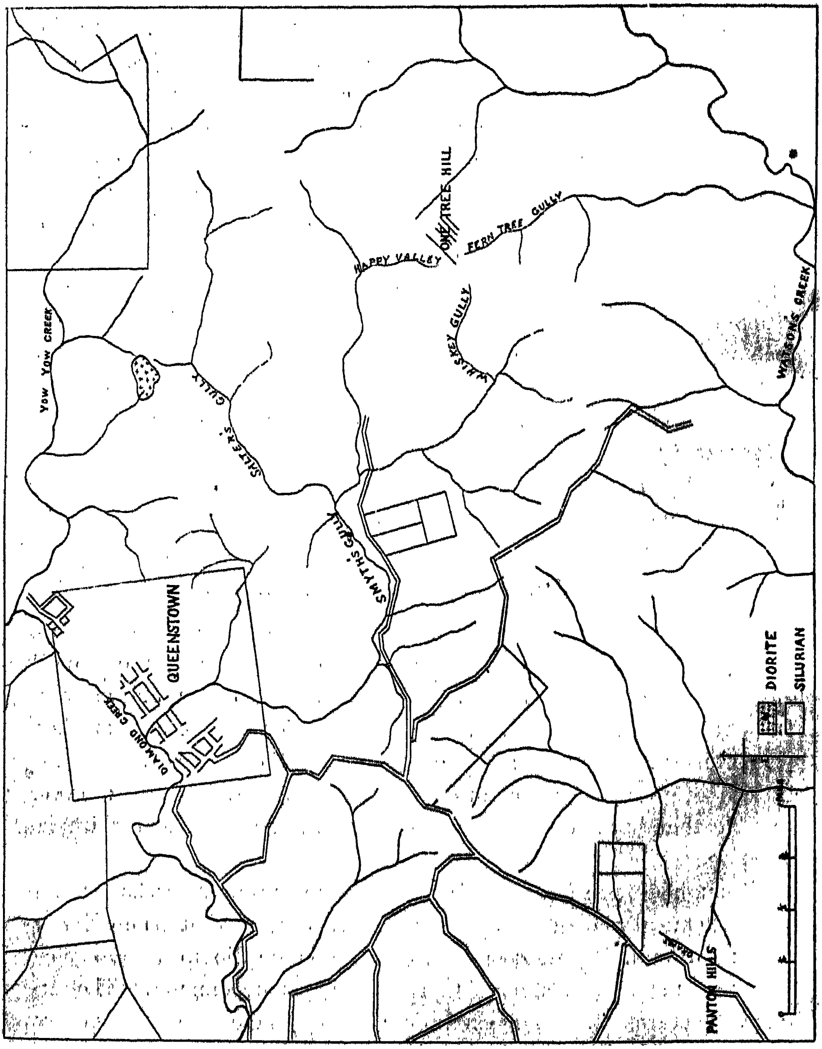
yield of Oram's reef. Hence, no conclusions can be drawn with certainty regarding the effects of secondary enrichment on these reefs, but the evidence, such as it is, supports the conclusion that the values have not been greatly affected. The thin character of the reefs, combined wtih their comparative density, tends to inhibit extensive circulation of surface solutions, and hence to prevent solution of the gold. The rich patches found near the surface at One Tree Hill might be considered as suggestive of secondary enrichment, but the evidence, although not conclusive, does not support such a view. It appears fairly evident from the nuggets found in the alluvial at Cobbler's Gully, that the former upward extension of the Swedish reef was as rich, or even richer, than the portion now exposed to denudation and vadose solutions. It seems very likely, therefore, that the distribution of the gold in the Swedish reef near the surface, is not due to the present-day vadose circulation, but is due to conditions determining the primary deposition of the gold. Of such factors influencing the primary deposition, decrease of temperature and pressure, admixture with surface solutions, and indicator effects are the most important. There is fairly good reason to believe that the formation of these reefs took place soon after the folding of the sediments, and it is certain that several thousands of feet of these have been denuded away. Hence the assumption does not seem to be unwarranted that the primary deposition of the gold, in the portion of the reef now exposed, was not affected by admixture with surface solutions, and presumably not to any marked degree by reduction of temperature and pressure. We are left to deal with the effects of indicators. At Ballarat East, where nuggety gold occurs in the reefs, often at considerable depths, the nuggets are localised to near the intersection of the vein quartz with their seams termed "indicators." Unfortunately, the Swedish reef at One Tree Hill was not being worked at the time of my visit, and the records do not mention the mode of the occurrence of the gold, so that positive evidence, bearing on this question, is not forthcoming. However, Mr. Hirt, who, as previously mentioned, has been on this field most of his life, and whose word I have no reason to doubt, has informed me that the rich patches of gold, from the Swedish reef, were generally localised to near the intersection of the main reef with rather flat leaders of pinkish coloured quartz, two inches or so in width. If this is so, there appears to me to be no valid reason why other "indicator" veins and rich patches of gold should not be found in depth. As far as I am aware, the Swedish reef has not

been prospected below 200 feet, although the records mention the driving of a tunnel from Fern Tree Gully to prospect the Swedish reef in depth, but it is doubtful whether they ever worked this reef. Messrs. Hirt and Gerlach have recently driven a tunnel from the head of Cobbler's Gully to cut the Swedish reef, but at the time of my visit, they appeared to have not been successful in locating it. It is at least certain that there is no geological evidence in support of the view that the gold does not go down, and in the case of the Swedish reef the possible occurrence of other rich patches of gold in depth, has not been disproved. From the birth of this field the reefs have been worked almost entirely by individual miners or small parties, and companies were practically unknown. This is probably one important reason why the mines were abandoned at such shallow depths. The presence of water and the need of pumping machinery, harder ground, increased haulage, and the difficulty of following such narrow reefs, all contended against the enterprising individual, but such mines could, in many cases, be worked at a profit by small companies, with judicious expenditure and economical methods of working.

4.—Summary and Conclusions.

Until further palaeontological work has been attempted in this area, no definite opinion can be expressed relative to the age of these beds, near Queenstown. A stratigraphical comparison with the strata at Diamond Creek and Yarra Glen, suggests that they are intermediate in age between those at the above places, and are, therefore, either Melbournian or Yeringian. It is, however, possible that both series are represented in the area dealt with in this paper.

Although diorite is a popular field name for many rocks in Victoria, chemical and petrological examination show that true diorites are exceptional. The association of hornblende diorites, with gold-bearing quartz in Eastern Australia, is not uncommon. The extensive metasomatic changes undergone by these rocks frequently accompanies the introduction of the auriferous quartz. The Queenstown diorite has been shown to be closely allied to the Morning Star diorite, Wood's Point, and has suffered similar alteration. Two independent types of metasomatic alteration can be recognised in the Queenstown diorite—(1) A propylitic alteration at relatively high temperature and pressure, resulting in the formation of chlorite and epidote after hornblende; the development of pyrrhotite



Geological Sketch Map of portion of the Parishes of Queenstown and Greensborough. Reproduced from Mr. O. A. L. Whitelaw's maps of these Parishes.

Fig. I.

Fig. II.

Fig. III.

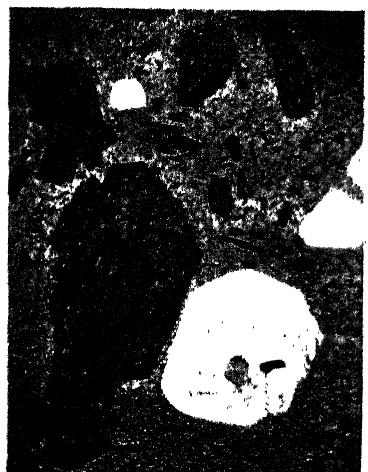


Fig. IV.

after ilmenite, and the formation of calcite and a little sericite. Chemical changes in the rock are slight. (2) Alteration by the vein solutions. The chief effects are extensive development of sericite after felspar, and of carbonates, pyrites and muscovite, after chlorite and remaining hornblende. Chemical migrations are probably great. The relative proportions of the alkalies, for instance, are reversed.

The latter part of the paper deals with certain characteristics of an important, but now forgotten, gold field. Of particular interest was the occurrence of large nuggets at One Tree Hill, clearly derived from the Swedish reef which was known to be nuggety near the surface.

In concluson, the writer wishes to record his indebtedness to Mr. A. M. Howitt, of the Victorian Geological Survey, for drawing his attention to the record of alluvial nuggets found on this field; to Mr. Chapman, for identification of a few fossils; and to Messrs. Tallin and Mann, of the Imperial College of Science, London, and the Melbourne University, Geological Departments, respectively, for numerous rock sections, and Professor Skeats and the Secretary for Mines of Victoria, for help in obtaining Parish Plans of the area.

EXPLANATION OF PLATE XIX.

Fig. 1.—Microphotograph of Quartz Diorite, Caledonia Mine, Queenstown, × 16, ordinary light. The black areas represent ilmenite, and the striated phenocryst is hornblende partially altered to light coloured chlorite and epidote.

Fig. 2.—Microphotograph of Quartz Diorite, Caledonia Mine, Queenstown, × 20, crossed nicols; showing well-zoned plagioclase phenocrysts.

Fig. 3.—Microphotograph of highly metasomatically altered Diorite, near a quartz vein, Caledonia Mine, Queenstown, × 16, ordinary light. Q = quartz, F = highly sericitised felpar, M = muscovite and carbonate replacing chlorite after hornblende, P = pyrite, As = arsenopyrite, S = stibnite.

Fig 4.—Microphotograph of metasomatically altered Quartz-Felspar-Porphyry, One Tree Hill, × 11, ordinary light; showing phenocrysts of colourless quartz, idiomorphic sericitised and carbonated orthoclase, and rectangular sections of muscovite after biotite.

END OF VOLUME XXVII., PART I.

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ART. XII.—*Studies in the Physical Chemistry of Essential Oils.*

PART I.—*The Physical Properties of mixtures of two Terpene substances in relation to those of the constituents.*

BY

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AND

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(Communicated by W. Heber Green).

[Read 9th July, 1914).

It is of considerable interest to regard the mixture of organic bodies which is presented to us by an essential oil from a physico-chemical, as well as from the ordinary systematic point of view. We have here a class of mixtures, easily obtained in quantity, whose constituents are mostly well-known, and of allied structure; conditions which suggest a novel method of attacking the general theory of solution, and should also give us valuable data for judging the general composition of an oil from its physical constants—a problem of interest, both from the commercial and from the scientific standpoint.

As showing the questions which meet us here we may cite as an instance two eucalyptus oils from the same species, which yielded the same percentage of phellandrene $[\alpha = -69°]$ and contained no other optically active substance, whose rotations were as far distinct as $-23°$ and $-44°$ respectively.

The major portion of an essential oil usually consists of one or more terpenes. These may be considered as simple examples of non-ionising, unassociated solvents, and it will be well, therefore, to start our inquiry into essential oil equilibria by the study of these simple substances, adding progressively more complex or more reactive constituents. such as oxygenated derivatives, etc., and essaying to evaluate the new solution factors as they occur.

An ideal investigation, then, would start from the simplest case—a mixture of two terpenes—proceed through increasing complexity in the number and nature of the components, and finally reach that complicated equilibrium presented by a natural essential oil, such as that of Eucalyptus globulus.

The following results are of a preliminary nature, and are concerned with the simpler cases of such an inquiry.

Experimental.

The method followed in the measurements here recorded was to make mixtures of various concentrations from materials prepared as freshly as possible. The density, refractive index, and rotation of these were taken at 25° C., with such methods and precautions as accurate physicochemical work suggests.

The pyknometer held about 6 c.c's., and the temperature adjustment was correct to .01°. The rotations were taken in a 100 mm. tube in a Schmidt and Haensch polarimeter, and the refractive indices in a Zeiss refractometer, and for each of these the divergence in temperature did not exceed .1°.

The mixtures themselves were made up by successive additions of one constituent to a definite amount of the other—a method economical of material—and the results have shown it to be justified, for any systematic error arising from this cause would increase with each addition, and such increases have not appeared.

Calculation of Results.

We may comment here on the methods employed for calculating the theoretical value of any physical property of a liquid mixture. If the property under consideration is additive, and no anomaly is present, we have—

$$P_{(\text{calc.})} = \frac{m_1 P_1 + m_2 P_2}{m_1 + m_2}$$

where P_1, P_2, are the values of the property considered, for the individual substances, and m_1 and m_2 are the masses of these substances in the mixture. If the additive relationship does not hold, however, we must modify the formula to express the effects of the molecules, atoms or ions, which are the disturbing factor. Thus, if the molecules are the reacting entities to be considered, we have [M_1, M_2 being the molecular weights]—

$$P_{(\text{calc.})} = \frac{\dfrac{m_1 P_1}{M_1} + \dfrac{m_2 P_2}{M_2}}{\dfrac{m_2}{M_1} + \dfrac{m_2}{M_2}}$$

Since many factors in liquid mixtures are influencing a particular property, it is necessary to introduce more and more terms before we can attain concordance. But since the difficulty of in-

terpreting the equations so obtained, makes this rather a waste of labour, it suffices at present, where properties are atomic (*e.g.*, Refractivity) to use the first of these equations, while for those where the molecular influence is introduced (*e.g.*, Density) the second formula, giving what is known as the Molar Fraction, serves as some correction.

Hence, these two methods of calculation are all that have been employed in the present research.

The System l-pinene—d-pinene.

In considering the purity of the terpenes mentioned, it must be remembered that where suitable solid derivatives, from which a terpene may be regenerated in quantity, are wanting, the only means of purification is repeatedly to distil under diminished pressure. The product, of course, may be partly racemised, or may contain some of its optical isomers. For this reason the physical properties of two optical isomers, such as d- and l-pinene, are not numerically identical, a point which is of little significance in the present research, since these well-fractionated terpenes are "pure" from the practical point of view. Indeed, the l-pinene of rotation -39° is almost free from racemate, while the $+25^\circ$ rotation of the d-pinene is quite as high as other workers have usually obtained. In the mixture of these two isomers, from our standpoint, the simplest case, we should anticipate no constitutive effects, and indeed, the observed properties of the mixtures agree excellently with those calculated by (1), the simple mixture formula, and the slight deviations which occur may be taken as indicative of the magnitude of the experimental error in the other systems as well.

The pinenes were obtained from oils from Eucalyptus dextro pinea and E. laevopinea, which were generously given us by Mr. Smith, of the Sydney Technological Museum. He has worked out their composition, and his results we have confirmed, and by distilling in a rod and disk apparatus at 10 mm. pressure we have obtained pinene fractions with the following properties:—

At 25°C.	d-Pinene.	l-Pinene.
Rotation ...	+25.40°	−39.64°
Refractive Index	1.4640	1.4639
Density ...	.8604	.8646

THE SYSTEM D-PINENE—L-PINENE.

	l-pinene.	A.	B.	C.	D.	E.	d-pinene.
l-pinene Concentration	100	86.82	75.04	50.87	28.98	15.92	0
			Rotation—				
Found ...	−39.64°	−31.39°	−23.60°	−7.80°	+6.45°	+15.02°	+25.40°
Calc. ...	...	−31.37°	−23.66°	−7.83°	+6.51°	+15.05°	...
			Refractive Index—				
Found ...	1.4639	1.4641	1.4640	1.4640	1.4641	1.4640	1.4640
Calc. ...	...	1.4640	1.4640	1.4640	1.4640	1.4640	...
			Density—				
Found ...	.8646	.8639	.8633	.8626	.8614	.8610	.8604
Calc. ...	...	.8640	.8636	.8625	.8616	.8611	...

The Systems l-Pinene-Cineol and d-Pinene-Cineol.

Of greater complexity is the case involving a partial replacement of one of the terpenes by an oxygenated substance of allied structure. Cineol is such a substance, and with it the deviations from the simple proportionately become noticeable.

These deviations, as in the case of the specific rotatory power, may be due to a disturbance of the equilibrium, between active and racemic terpene, brought about by the cineol, a possibility supported by the fact that the refractivity is not affected.

It is in the density, however, that the divergences from the simple proportionality become most marked, and here it can be shown that the influence is molecular rather than structural, by the fact, that when the theoretical densities are calculated from the molar fractions they again agree with the observed. In the simpler case of d- and l-pinene the molar and weight fractions, of course, coincide, since the two molecular weights are the same.

The cineol was obtained from Bosisto's Ol. Eucalyptus B.P. by conversion into the phosphoric acid compound and regeneration with soda, after squeezing out the terpenes under pressure. The product was then distilled with steam, and its constants were—

$$\alpha = \pm 0.00^\circ$$
$$\mu_{25} = 1.4579$$
$$\delta_{25} = .9220$$

THE SYSTEM L-PINENE—CINEOL.

	Concentration l-pinene.						
	l-pinene.	A.	B.	C.	D.	E.	cineol.
Mol. p.c. ...	100	82.46	51.36	36.26	16.34	11.69	0
Wt. p.c. ...	100	80.26	48.24	33.44	14.71	10.47	0
			Rotation—				
Found ...	−39.64°	−32.38°	−19.65°	−13.67°	−5.98°	−4.25°	0°
Wt. p.c. ...	...	−32.13°	−19.31°	−13.38°	−5.89°	−4.19°	...
Mol. p.c. ...	...	−33.00°	−20.56°	−14.51°	−6.54°	−4.67°	...
			Refractive Index—				
Found ...	1.4639	1.4629	1.4608	1.4600	1.4587	1.4585	1.4579
Wt. p.c. ...	...	1.4628	1.4608	1.4600	1.4588	1.4585	...
			Density—				
Found ...	.8646	.8751	.8931	.9016	.9128	.9166	.9220
Wt. p.c. ...	...	.8760	.8944	.9029	.9136	.9169	...
Mol. p.c. ...	...	.8747	.8936	.9012	.9127	.9164	...

THE SYSTEM D-PINENE—CINEOL.

	Concentration d-pinene—						
	d-pinene.	A.	B.	C.	D.	E.	cineol.
Wt. p.c. ...	100	82.84	64.18	46.85	30.12	17.91	0
Mol. p.c. ...	100	84.54	66.98	49.95	32.80	19.81	0
			Rotation—				
Found ...	25.40°	21.22°	16.56°	12.07°	7.78°	4.60°	0°
Wt. p.c. ...	...	21.04°	16.30°	11.90°	7.65°	4.55°	...
			Refractive Index—				
Found ...	1.4640	1.4630	1.4618	1.4609	1.4598	1.4586	1.4579
Wt. p.c. ...	...	1.4630	1.4620	1.4609	1.4597	1.4588	...
			Density—				
Found ...	.8604	.8700	.8807	.8915	.9019	.9095	.9220
Wt. p.c. ...	...	.8709	.8825	.8931	.9034	.9110	...
Mol. p.c. ...	...	.8699	.8805	.8913	.9018	.9098	...
			Specific Rotary Power—				
Found ...	29.51°	24.39°	18.80°	13.54°	8.62°	5.06°	0°
Calc. ...	...	24.45°	18.94°	13.83°	8.89°	5.29°	...

The System Cineol-Citral.

Here one of the constituents of the mixture has an open chain. Unfortunately, the refractivities lie too close together for differences to be detected, and both substances are inactive.

The densities show fair agreement when calculated from molar fractions, but apparently other factors are introduced by the wider structural differences.

The citral was from Merck's, and was characterised as follows—

$$\delta_{25} = .8900$$
$$\mu_{25} = 1.4780$$

THE SYSTEM CINEOL–CITRAL.

	Citral.	A.	B.	C.	D.	E.	F.	cineol.
				Density—				
Found ...	.8900	.8946	.9001	.9021	.9066	.9096	.9124	.9220
Wt. p.c. ...	...	.8949	.9008	.9030	.9063	.9101	.9127	...
Mol. p.c. ...	...	.8948	.9007	.9026	.9063	.9099	.9126	...
				Concentration cineol—				
Wt. p.c. ...	0	15.24	33.73	40.35	50.98	62.62	70.70	100
Mol. p.c. ...	0	15.07	33.43	40.03	50.65	62.30	70.42	100

The Phellandrene Complex.

We hoped by these methods to obtain from the rotation of a Eucalyptus oil an indication of the amount of phellandrene it contained, and a series of l-phellandrene-cineol mixtures were made up. The preparation of the phellandrene has been elsewhere[1] described, and its constants were—

$$\alpha = -68.35^\circ$$
$$\mu_{25} = .8454$$
$$\delta_{25} = 1.4747$$

The results were rather surprising, for we found that if the measurements be taken immediately after mixing, the density and rotation agree closely with the calculated values, and the refractive index exactly, but the mixtures are unstable, rapidly decreasing in rotation, and increasing in density and refractive index. This change goes on most rapidly in the presence of light and oxygen, more slowly in the dark, and not at all, as far as we were able to make out, in the absence of oxygen.

Phellandrene itself rapidly changes under similar conditions, attaining equilibrium when its rotation is about +3°. We hope to discuss this matter more fully in a future paper.

THE SYSTEM L-PHELLANDRENE—CINEOL.

	Phellandrene.	A.	B.	C.	D.	E.	cineol.
				Rotation—			
Calc. ...	...	−13.63°	−27.54°	−41.43°	−54.75°	−40.76°	...
Obs. 20 hrs.	−68.35°	−12.90°	−25.15°	−39.85°	−52.50°	−40.06°	0°
Obs. 48hrs.	...	−12.60°	−21.63°	−36.75°	−46.82°	...	...
				Refractive Index—			
Calc. ...	...	1.4627	1.4659	1.4688	1.4719	1.4688	...
Obs. 1 hr....	1.4747	1.4628	1.4659	1.4688	1.4719	1.4688	1.4579
Obs. 44 hrs.	...	1.4631	1.4678	1.4699	1.4734	...	...
				Density—			
Calc. ...	...	.8980	.8845	.8714	.8585	.8719	...
Obs. 1 hr.	...	.8986	.8858	.8728	.8595	.8726	.9202
Obs. 44 hrs.	...	.9018	.8956	.8776	.8678	.8764	...
Concentration. ...	100	19.94	40.30	60.62	80.10	59.64	0

1 R. Barry Drew. Australian Association for the Advancement of Science. Report 1913.

Summary.

Simple mixtures of two terpene compounds follow the "Mixture Law" quite closely. The divergences, at any time small, are eliminated by the use of the "Molar Fraction Formula."

For such mixtures the proportions of the constituents can be calculated from the properties of the mixture, but where one constituent is unstable, as in phellandrene oils, such deductions are unreliable.

These measurements were made in the research laboratories of the University of Melbourne, for the use of which we have to thank Professor Masson.

Our thanks are also due to Professor Osborne for the use of his polarimeter, and especially to Mr. H. G. Smith for his generous gift of pinene eucalyptus oils.

Part II.—*The Physical Constants of some Terpenes and oxygenated derivatives thereof, and their variation with temperature.*

BY

E. IVAN ROSENBLUM, M.Sc.

(Communicated by W. Heber Green, D.Sc.).

[Read 9th July, 1914).

Some measurements which had been made in the course of the last paper, and the fact that he had on hand samples of a number of terpenes prepared for that research, led one of the authors to make a series of measurements on the influence of temperature change on the three chief physical constants of terpenes—Density, Refractive Index, and Rotation.

The terpenes employed are, in the main, those whose purification has been described in the joint paper; the others were as supplied by Merck and Kahlbaum, and, with two exceptions, their purity as indicated by their constants and by the usual tests was such as to render it unnecessary to submit them to the somewhat uncertain processes involved in further purification.

The density and refractive index of the terpineol indicate that it is mainly the isomer of M. Pt. 35° – 36° C., while the high density and diminished rotation of the d-limonene point to some modification having occurred since it was originally prepared by Kahlbaum.

Although the uncertain purity which is inherent to the terpenes renders these results less valuable from the point of view of physico-chemical theory, they may none the less be regarded as standards by workers in the fascinating field of Essential Oils.

Substance.	Source.	Constants at 20°C.		
		δ	n	α
l-phellandrene ...	Eucalyptus dives oil ...	.8551	1.4783	– 65.11°
d-pinene ...	E. dextropinea oil ...	.8682	1.4659	+ 25.14°
l-pinene ...	E. laevopinea oil ...	.8668	1.4665	– 39.81°
pinene ...	American turpentine ...	.8603	1.4690	+ 1.0°
d-limonene ...	Kahlbaum	.8922	1.4814	+ 81.95°
cineol ...	Bosisto, Melbourne ...	.9239	1.4598	± 0.00°
eugenol ...	Merck	1.0667	1.5415	± 0.03°
safrol ...	Merck	1.1003	1.5385	± 0.00°
terpineol ...	Merck	.9354	1.4835	+ 0.04°
citral ...	Merck	.8912	1.4889	± 0.00°

(1) The Density.

The densities were measured at ten degree intervals between 10° and 60° by means of a pyknometer holding about 6 c.c., and a bath, which could be maintained at any required temperature, while a measurement was in progress. Incidental errors due to expansion of the glass of the pyknometer, etc., were eliminated by taking a series of pyknometer values for distilled water over the temperature range, calculating the specific gravity from these, and then deriving the density as referred to water at 4° C. from the tables of the density of water.

These densities at ten-degree intervals are shown in the accompanying table.

It will be observed that, while the coefficients of expansion are in all cases close together, they fell into two groups, the oxygenated substances cineol, safrol and eugenol expanding to a greater degree than the hydrocarbons.

Citral, the only straight chain terpene, and terpineol, are exceptional. The relation of temperature to density is strictly linear except in the case of the ever-exceptional l-phellandrene, where a slight divergence is shown.

THE DENSITIES.

Substance.	10°	20°	30°	40°	50°	60°		Coeff.
l-phellandrene	.8635	.8551	.8469	.8387	.8306	.8224	...	.000826
d-pinene ...	.8763	.8682	.8602	.8522	.8442	.8361	...	807
l-pinene ...	.8750	.8668	.8586	.8504	.8422	.8340	...	821
pinene ...	.8685	.8603	.8521	.8439	.8356	.8274	...	822
d-limonene ...	.9004	.8922	.8840	.8759	.8679	.8599	...	811
cineol ...	.9324	.9239	.9153	.9067	.8982	.8896	...	857
eugenol ...	1.0754	1.0667	1.0579	1.0492	1.0404	1.0316	...	876
safrol ...	1.1090	1.1003	1.0915	1.0828	1.0740	1.0652	...	876
terpineol ...	.9432	.9354	.9276	.9198	.9120	.9042	...	780
citral ...	.8992	.8912	.8832	.8752	.8671	.8891	...	800

(2) The Refractive Index.

Of recent papers on the relation between refractive index and temperature the most interesting are those of Falk[1], who found a linear relation for those substances he examined, none of which, however, were terpenes.

In the present research in every case there are found divergences from this simple proportionality, the temperature coefficient increasing with the rise of temperature except in the cases of cineol and of l-pinene, where it decreases, and the divergences being most marked in the results for l-phellandrene.

Like the coefficients of expansion, these temperature coefficients vary only within narrow limits from .000402 for d-pinene to .000480 for l-phellandrene. Since the coefficients for those organic substancs, whose refractive indices are tabulated in Landolt-Bornstein, vary from .0003 to .0008, this magnitude appears to be a constitutional one. The measurements of refractive index between 10° and 60° are tabulated in the table. They were obtained in a Zeiss refractometer, fitted with a constant temperature device, which ensured constancy to at least .1°.

Three formulae have been suggested for calculating the refractive power—

$$(1)\ n-1/d \quad (2)\ n^2-1/d \text{ and } (3)\ n^2-1/(n^2+2)d$$

and Falk found that n^2-1/d gave values that decreased as the temperature rose, $n^2-1/(n^2+2d)$ values that increased, while, when $n-1/d$ was used for the calculation, they increased in some cases and decreased in others.

1 J. Amer. Chem. Soc., 1909, 31, 86, 806.
Zeit. Physik. Chem., 1913, 82, 504.

This has been confirmed for the terpenes used in the present research, and since the $n-1/d$ figures approach more closely to constancy than those based on the other two formulæ, they have been adopted for comparing the molecular refractive powers.

The constants are calculated by the three formulæ for cineol, l-phellandrene and l-pinene are shown in a table, and the values of $n-1/d \times M$ are shown for all the substances, plotted against the temperatures.

These curves do not show much agreement with one another, the greatest deviations being, as usual, shown by l-phellandrene; but it will be seen that the influence of temperature, though small, is regular, and gives smooth curves.

Eisenlohr[1] has recently obtained as accurately as possible a series

REFRACTIVE INDICES.

Substance.	10°	20°	30°	40°	50°	60°		Average coeff.
l-phellandrene	1.4822	1.4783	1.4742	1.4695	1.4642	1.4582	...	.000480
d-pinene ...	1.4698	1.4659	1.4619	1.4578	1.4537	1.4497	...	.000402
l-pinene ...	1.4713	1.4665	1.4617	1.4570	1.4525	1.4481	...	.000464
pinene ...	1.4734	1.4690	1.4645	1.4598	1.4549	1.4499	...	.000470
d-limonene ...	1.4857	1.4814	1.4769	1.4723	1.4677	1.4630	...	.000454
cineol ...	1.4648	1.4598	1.4550	1.4505	1.4462	1.4420	...	.000456
eugenol ...	1.5455	1.5415	1.5374	1.5329	1.5282	1.5236	...	.0004
safrol ...	1.5425	1.5385	1.5343	1.5300	1.5252	1.5205	...	.000440
terpineol ...	1.4878	1.4835	1.4792	1.4748	1.4706	1.4664	...	.000428
citral ...	1.4929	1.4889	1.4848	1.4802	1.4752	1.4700	...	.000458

REFRACTIVE POWERS BY VARIOUS FORMULAE.

l-phellandrene.					*l-pinene.*			
t°	n^2-1/d	$n-1/d$	$n^2-1/(n^2+2)d$		t°	n^2-1/d	$n-1/d$	$n^2-1/(n^2+2)d$
10	13868	5584	3302	...	10	13321	5386	3198
20	13851	5593	3312	...	20	13280	5382	3199
30	13849	5598	3323	...	30	13234	5378	3199
40	13827	5597	3324	...	40	13206	5374	3203
50	13770	5588	3318	...	50	13178	5372	3206
60	13696	5571	3319	...	60	13152	5372	3210

Cineol.					*Citral.*			
t°	n^2-1/d	$n-1/d$	$n^2-1/(n^2+2)d$		t°	$n^2\ 1/d$	$n-1/d$	$n^2-1/(n^2-2)d$
10	12290	4985	2964	...	10	13663	5482	3231
20	12242	4976	2963	...	20	13653	5485	3238
30	12205	4971	2964	...	30	13639	5488	3244
40	12175	4968	2967	...	40	13605	5487	3247
50	12150	4968	2970	...	50	13565	5481	3248
60	12135	4967	2976	...	60	13515	5472	3249

[1] Zeit. Physik. Chem., 1911, 75, 585.

MOLECULAR REFRACTIVE POWER $n-1/d.M$

Substance.	10°	20°	30°	40°	50°	60°
l-phellandrene ...	75.94	76.06	76.13	76.12	76.00	75.77
d-pinene	72.92	72.96	73.03	73.08	73.12	73.16
l-pinene	73.24	73.18	73.14	73.08	73.06	73.05
pinene	74.14	74.15	74.14	74.11	74.05	73.96
d-limonene	73.36	73.38	73.37	73.33	73.29	73.23
cineol	76.76	76.62	76.54	76.50	76.49	76.48
eugenol	83.20	83.26	83.32	83.30	83.26	83.23
safrol	79.26	79.29	79.32	79.30	79.24	79.18
terpineol	79.66	79.61	79.57	79.52	79.48	79.44
citral	83.32	83.37	83.42	83.40	83.31	83.18

MOLECULAR REFRACTIONS AT 20°

a. Found [$n^2-1/(n^2+2)d.M$ formula]

b. Calculated from Atomic Refractions[1]

Substance.	*a.*	*b.*
l-phellandrene	45.05	45.25
d-pinene	43.37	43.51
l-pinene	43.48	43.51
pinene	44.03	43.51
d-limonene	43.42	45.25
cineol	45.63	45.62
eugenol	48.35	47.37
safrol	46.08	45.40
terpineol	46.45	45.04
citral	49.22	46.78

of atomic refractions, and these have been used to calculate the theoretical molecular refractions. As will be seen, these are in excellent agreement with the experimental values in some cases, but in others, as in that of citral, where the constants of the sample showed it to be of quite satisfactory purity, the large divergence is difficult to account for. In the cases of eugenol, safrol, and terpineol, it may be due in part to the unknown influence of ring formation.

The value for phellandrene lends some support to Wallach's formula for that terpene, in that it indicates two double bonds.

(3) *The Rotation.*

Considerable attention has been devoted to the influence of temperature on rotation, and from the work of a number of chemists it appears that the rotation of solids dissolved in non-active sol-

1 Eisenlohr. Zeit. Physik. Chem., 1911, 75, 485.

vents increases when the temperature rises, while that of optically active liquids decreases.

Guye and Aston[1] examined some fifty organic liquids, and found that in all cases except that of amyl alcohol the rotatory power diminished with rise of temperature. This exceptional case they explained by the dissociation of previously associated molecules.

The rotations of the only four terpenes which were optically active were measured over a range of from 20° to 60° by means of a Pülfrich polarimeter, fitted with a device for varying the temperature of the tube by means of a bath, and the experimental values are shown in the accompanying table, while the molecular rotatory powers – $a/l . 1/d$. M – have also been calculated and plotted against the temperature.

The rotations of d- and l-pinene are little affected by temperature change, but slowly decrease as the temperature rises. That of d-limonene falls 0.134° for every degree rise of temperature, while phellandrene again shows its abnormal character by a marked increase of rotation.

In every one of its physical properties then, the curious nature of this terpene, as obtained from the oil of Eucalyptus dives, is expressed. It appears as if it must either be a mixture of two terpenes inseparable by distillation, whose equilibrium is upset by temperature change, or, as seems more probable, the molecules may be associated at the lower temperatures, as in the case of amyl alcohol.

Further work may shed more light on this interesting terpene.

ROTATION.

t°	l-phellandrene.	d-pinene.	d-limonene.	l-pinene.
15°	...	...	...	−40.01°
20°	−65.11°	+25.11°	+81.92°	−39.86°
25°	−65.55°	+25.09°	+81.44°	−39.63°
30°	−66.08°	+25.05°	+80.74°	−39.46°
40°	−67.02°	+24.92°	+79.19°	−39.09°
50°	−67.93°	+24.78°	+77.66°	−38.76°
60°	−69.02°	+24.62°	+76.49°	−38.44°
70°	−70.00°	...	+74.85°	...

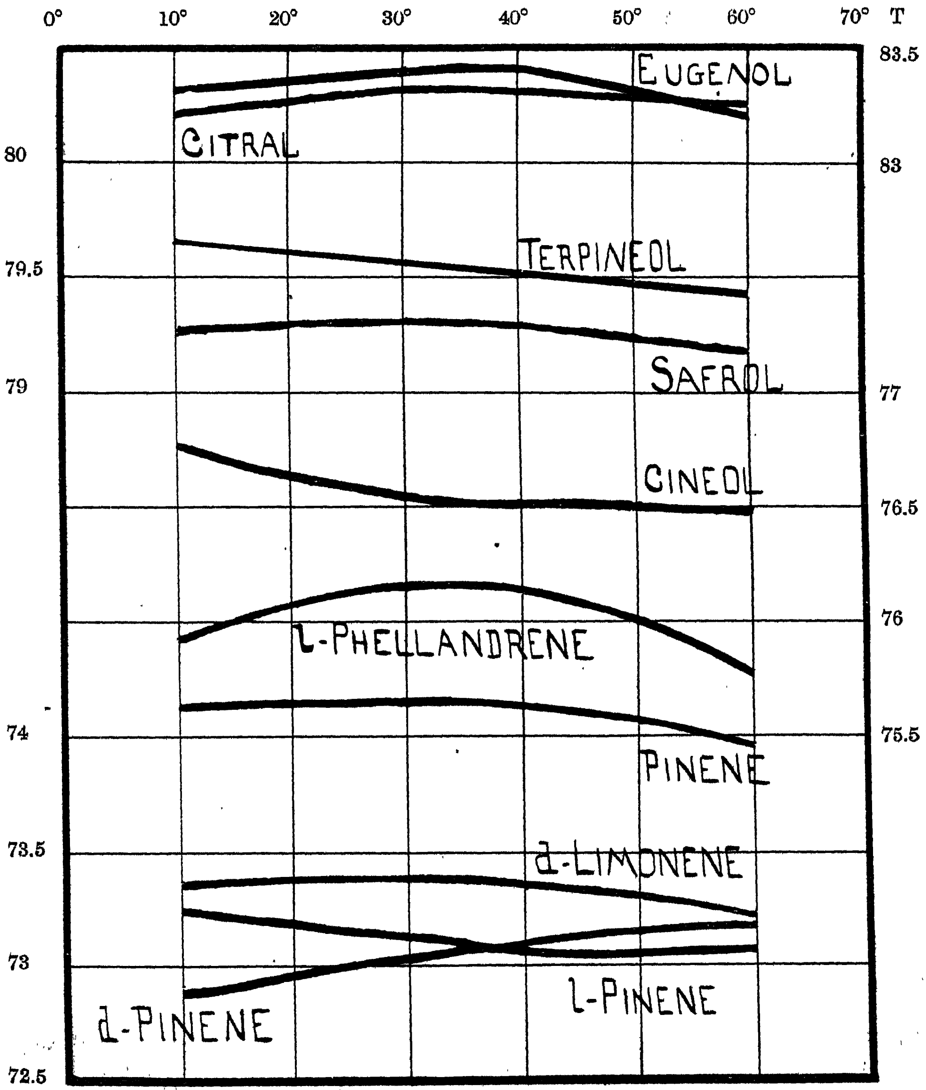
MOLECULAR ROTATIONS $\frac{a}{l} . \frac{1}{d}$. M

Substance.	20°	30°	40°	50°	60°
l-phellandrene ...	103.56	106.12	108.73	111.34	114.08
d-pinene	39.38	39.54	39.72	39.90	40.08
l-pinene	62.42	62.52	62.58	62.63	62.69
d-limonene ...	124.92	124.33	123.48	122.43	121.30

1 Compt. Rend., 1897, 124, 194-197.
Compt. Rend., 1897, 125, 819-821.

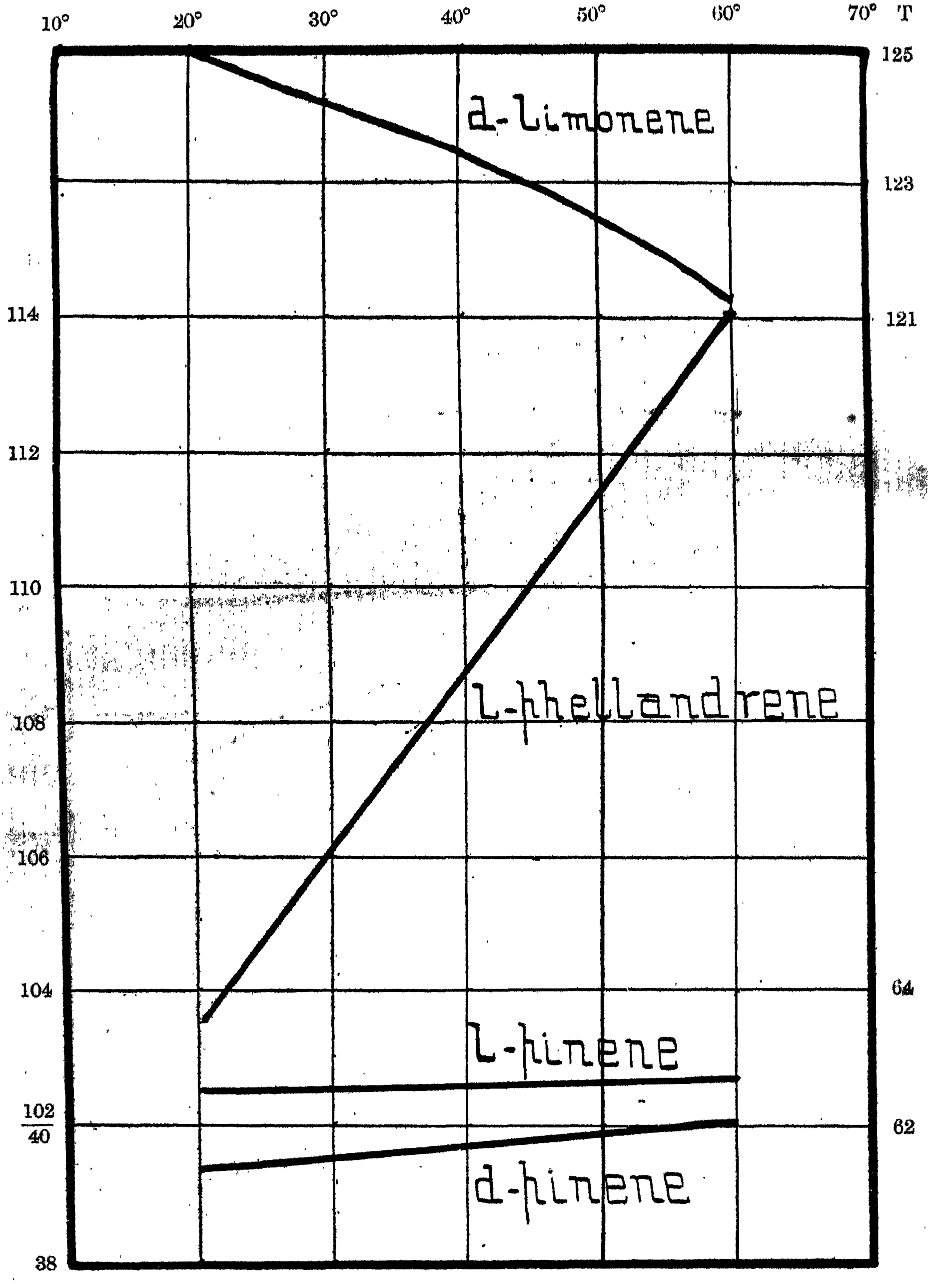
I.

MOLECULAR REFRACTIVE POWER $\frac{M(n-1)}{d}$



II.

MOLECULAR ROTATORY POWER.



COEFFICIENTS.

Substance.	Density.	Refr. Index.	Rotation.
l-phellandrene ...	.000826	.000480	+.097
d-pinene	807	402	-.013
l-pinene	821	464	-.034
pinene	822	470	...
d-limonene	811	454	-.132
cineol	857	456	...
eugenol	876	458	...
safrol	876	440	...
terpineol	780	428	...
citral	802	458	...

Summary.

1. The influence of temperature change on the density, refractive index, and rotation of a number of terpenes and allied substances has been studied.

2. In the cases of density and refractive index the temperature coefficients all lie close together, while the divergences from a linear relation are slight.

3. Laevo-phellandrene, as obtained from the oil of Eucalyptus dives, is in all its relations somewhat abnormal, and the suggestion is made that it may form associated molecules at the lower temperatures.

The thanks of the author are due to Dr. Heber Green for the interest he has shown in this research.

[Proc. Roy. Soc. Victoria, 27 (N.S.), Pt. II., 1914].

Art XIII.—*Singular Parameter Values in the Boundary Problems of the Potential Theory.*

By C. E. WEATHERBURN, M.A., B.Sc.
(Ormond College, University of Melbourne).

[Read 9th July, 1914].

The method of integral equations has been successfully applied to the boundary problems requiring the determination of potentials, W(p) and V(p) satisfying the boundary relations[1] —

$$(1)\qquad \begin{cases} \tfrac{1}{2}[W(t+) - W(t-)] - \tfrac{1}{2}\lambda[W(t+) + W(t-)] = f(t) \\ \tfrac{1}{2}\Big[\dfrac{dV}{dn}(t-) - \dfrac{dV}{dn}(t+)\Big] - \tfrac{1}{2}\lambda\Big[\dfrac{dV}{dn}(t-) + \dfrac{dV}{dn}(t+)\Big] = f(t) \end{cases}$$

respectively, whether the potentials are ordinary[2] corresponding to Laplace's equation, or "generalised" corresponding to the equation—

$$(2)\qquad \nabla^2 U - k^2 U = 0$$

The latter potential I have considered in a paper[3] recently communicated to the Quarterly Journal. It is shewn that solutions to the problems can be uniquely determined, except for certain singular values of the parameter, in the form of potentials of double and simple strata respectively, given by[4]—

$$(3)\qquad \begin{cases} W(p) = \int f(t) H(tp)\, dt \\ V(p) = \int G(pt) f(t)\, dt. \end{cases}$$

At a singular parameter value λ_0, however, the solutions become infinite; since each of the functions H(tp) and G(pt) has a simple pole, unless certain conditions are satisfied. It will be shewn that the parts $H(tp)$ and $G(pt)$ of these functions remaining finite at the pole λ_0, form the corresponding functions for the solutions at this pole of the problems (1), which, however, must be modified[5] in their second members. The residues P(tp) and Q(pt) of H(tp) and G(pt) respectively, also play an important part in the following argument.

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1 Poincaré. "Sur les équations de la Physique." Rendiconti, Palermo, 1894.

2 Plemelj. Monatsfefte für Math. und Physik, Bd. 15, S. 337-411 (1904); Bd. 18, S. 180-211 (1907).

3 "Boundary problems for the generalised potential corresponding to the equation $\nabla^2 U - k^2 U = 0$." Quarterly Journal, vol. 46, pp. 66-82.

4 The integration throughout is extended over the boundary of the region considered, unless otherwise stated. The notation of my previous paper is adhered to.

5 Weatherburn, loc. cit. § 6; also Plemelj, loc. cit., S. 404-5.

Plemelj's work[1] is confined to the ordinary potential and deals chiefly with the pole $\lambda = +1$. The present paper extends the investigation to the generalised potential, and also to the general pole λ_0. For this characteristic number, which may be any whatever, more general relations are established connecting the residues and the functions $H(tp)$ and $G(pq)$, which correspond to the modified problems. The boundary discontinuities of these functions and their derivatives are investigated, and also certain theorems of reciprocity. Expansions for the various functions are found as power series in the parameter λ.

In the first part of the paper the investigation applies to the ordinary and generalised potentials alike. In the second part the ordinary potential is considered separately, and results peculiar to Laplace's equation are obtained which depend either upon the fact that $\lambda = \pm 1$ are here characteristic numbers, or upon the special value of the integral of $h(tp)$ extended over the boundary. Values for the boundary integrals of the different functions are investigated. Further from the convergence of the above expansions when $|\lambda| = 1$ a value is deduced for the conductor potential. It will also be shown that the solutions of the second boundary problem for the inner and outer regions are expressible in terms of a single function.

Finally the case of the generalised potential is considered separately. The value is found of the integral of $h(tp)$ extended over the boundary, in terms of the potential of a space distribution of matter. Further relations are found connecting the boundary integrals of the other functions involved.

I.—*Ordinary and generalised potentials.*

§1. *Solutions and their poles.* The solutions of the boundary problems as given by (3), when expressed in terms of the resolvent $\mathrm{H}(ts)$ become[2]—

$$(3') \qquad \begin{cases} \mathrm{W}(p) = \int \mathfrak{f}(t)[h(tp) + \lambda \int \mathrm{H}(t\theta)h(\theta p)d\theta]dt \\ \mathrm{V}(p) = \int [g(pt) + \lambda \int g(p\theta)\mathrm{H}(\theta t)d\theta]\mathfrak{f}(t)dt \end{cases}$$

where

$$h(\theta p) = \frac{d}{dn} g(\theta p)$$

θ being a point on the boundary, and $g\ (pq)$ is a particular solution of Laplace's equation if the potential is ordinary, and of the equation (2) if it is generalised. The value of this function is given by—

1 Cf. also "Potentialtheoretische Untersuchungen," Teubner, Leipzig (1911).

2 Cf. Weatherburn. Loc. cit. § 2.

$$(4) \qquad \begin{cases} g(pq) = \frac{1}{\pi}\log\frac{1}{r} \text{ for the logarithmic potential} \\ g(pq) = \frac{1}{2\pi}\cdot\frac{1}{r} \text{ for the Newtonian potential} \end{cases}$$

which are solutions of Laplace's equation; and

$$(4') \qquad \begin{cases} g(pq) = \frac{1}{\pi}f(kr) \text{ for the plane} \\ g(pq) = \frac{1}{2\pi}\cdot e^{-kr}/r \text{ for space} \end{cases}$$

when the potential is generalised corresponding to the equation (2). In this r is the radius vector joining the points p and q, and $f(z)$ has the same meaning as in my paper already referred to. The functions $\mathrm{H}(tp)$ and $\mathrm{G}(pt)$ are equal to the corresponding expressions of (3′) in square brackets. The former is an extension of the solving function in which any point p replaces the boundary point s. The latter may be defined more generally for any two points pq by—

$$\mathrm{G}(pq) = g(pq) + \lambda\int g(p\theta)\mathrm{H}(\theta q)d\theta$$

This function is the Green's function[1] for the boundary problems (1). It will be seen that $\mathrm{H}(tp)$ can be expressed in terms of it by normal differentiation, so that both solutions (3) can be given in terms of it by a representation of Green's type. It is easily verified that

$$\int g(qt)\mathrm{H}(tp)dt = \int \mathrm{G}(qt)h(tp)dt$$

so that the equations defining and connecting these functions are—

$$(5) \qquad \begin{cases} \mathrm{H}(tp) - h(tp) = \lambda\int h(t\theta)\mathrm{H}(\theta p)d\theta = \lambda\int \mathrm{H}(t\theta)h(\theta p)d\theta \\ \mathrm{G}(qp) - g(qp) = \lambda\int g(q\theta)\mathrm{H}(\theta p)d\theta = \lambda\int \mathrm{G}(q\theta)h(\theta p)d\theta \end{cases}$$

Now when λ is equal to a characteristic number (singular value) λ_0, each of the functions $\mathrm{H}(tp)$ and $\mathrm{G}(qp)$ has a simple pole.[2] The solutions expressed by (3) are therefore infinite, and cease to have a meaning. Since the pole is simple we may write—

$$(6) \qquad \begin{cases} \mathrm{H}(tp) = H(tp) + \dfrac{\mathrm{P}(tp)}{\lambda_0 - \lambda} \\ \mathrm{G}(qp) = G(qp) + \dfrac{\lambda_0\mathrm{Q}(qp)}{\lambda_0 - \lambda} \end{cases}$$

where $H(tp)$ and $G(qp)$ are functions of λ, which depend on λ_0 and remain finite when $\lambda = \lambda_0$; the residues $\mathrm{P}(tp)$ and $\lambda_0\ \mathrm{Q}(qp)$ do not involve λ but depend on λ_0. If now we substitute from (6) in (5), multiply by $(\lambda_0 - \lambda)$ and proceed to the limit $\lambda = \lambda_0$, we obtain the following relations:—

$$(7) \qquad \begin{cases} \mathrm{P}(tp) = \lambda_0\int \mathrm{P}(t\theta)h(\theta p)d\theta = \lambda_0\int h(t\theta)\mathrm{P}(\theta p)d\theta \\ \mathrm{Q}(qp) = \int g(q\theta)\mathrm{P}(\theta p)d\theta = \lambda_0\int \mathrm{Q}(q\theta)h(\theta p)d\theta \end{cases}$$

1 Cf. Weatherburn. "Green's Functions for the equation $\Delta^2 u\ \ k^2u=0$, etc." Quarterly Journal, vol. 46. The remaining references are to my earlier paper.

2 Weatherburn. Loc. cit. § 3.

If again we substitute from (6) in (5) and use the relations (7) we find—

$$(8)\quad \begin{cases} \lambda\int h(t\theta)H(\theta p)d\theta = \lambda\int H(t\theta)h(\theta p)d\theta = H(tp) - h(tp) + \dfrac{1}{\lambda_0}.\mathrm{P}(tp) \\ \lambda\int g(q\theta)H(\theta p)d\theta = \lambda\int G(q\theta)h(\theta p)d\theta = G(qp) - g(qp) + \mathrm{Q}(qp) \end{cases}$$

These relations are more general than those found for the ordinary potential by Plemelj, who considers mainly the pole $\lambda = +1$. They play an important part in our argument.

The value of $\mathrm{P}(ts)$ is known, being the residue of the resolvent for the simple pole λ_0. If m be the order of multiplicity of the root λ_0 of the determinant $\mathrm{D}(\lambda)$, $\mathrm{P}(ts)$ may be expressed as the sum

$$(9)\qquad \mathrm{P}(ts) = \phi_1(t)\psi_1(s) + \phi_2(t)\psi_2(s) + \dots + \phi_m(t)\psi_m(s)$$

where the functions ϕ_i, $\psi_i(i=1, 2, \dots m)$ are the m linearly independent solutions of the homogeneous integral equations.

$$\begin{cases} \phi(t) = \lambda_0\int h(t\theta)\phi(\theta)d\theta \\ \psi(t) = \lambda_0\int \psi(\theta)h(\theta t)d\theta \end{cases}$$

satisfying the usual orthogonal relations. Hence the values of $\mathrm{P}(tp)$ and $\mathrm{Q}(qp)$ are given by

$$(9')\qquad \begin{cases} \mathrm{P}(tp) = \phi_1(t)\psi_1(p) + \dots\dots + \phi_m(t)\psi_m(p) \\ \mathrm{Q}(qp) = \Phi_1(q)\psi_1(p) + \dots\dots + \Phi_m(q)\psi_m(p) \end{cases}$$

where $\Phi(q)$ is the potential of a simple stratum of density $\phi(t)$ over the boundary, and $\psi(p)$ is that of a double stratum of moment $\lambda_0\psi(t)$.

If we introduce the functions

$$(10)\qquad \begin{cases} k(tp) = h(tp) - \dfrac{1}{\lambda_0}\mathrm{P}(tp) \\ l(qp) = g(qp) - \mathrm{Q}(qp) \end{cases}$$

we are enabled to express (8) in a form exactly similar to (5). For if in the first of (8) we replace p by θ, multiply throughout by $\mathrm{P}(\theta p)$ and integrate over the boundary, we find in virtue of (7) that

$$\int H(t\theta)\mathrm{P}(\theta p)d\theta = \int \mathrm{P}(t\theta)H(\theta p)d\theta = 0.$$

Similarly it may be proved that

$$\int G(q\theta)\mathrm{P}(\theta p)d\theta = \int \mathrm{Q}(q\theta)H(\theta p)d\theta = 0.$$

These integrals may therefore be combined with the integrals in (8) without altering their values, so that the relations may be written

$$(11)\qquad \begin{cases} \lambda\int k(t\theta)H(\theta p)d\theta = \lambda\int H(t\theta)k(\theta p)d\theta = H(tp) - k(tp) \\ \lambda\int l(q\theta)H(\theta p)d\theta = \lambda\int G(q\theta)k(\theta p)d\theta = G(qp) - l(qp) \end{cases}$$

which are of the same form as (5); but $G(qp)$, as will be seen, is the Green's function for the modified problems, and $H(tp)$ bears the same relation to it that $\mathrm{H}(tp)$ bears to $\mathrm{G}(qp)$..

§2.—*Boundary discontinuities.*—The second of equations (9) shows that Q (qp), regarded as a function of q, is the potential of a simple stratum of density $P(\theta p)$. From the boundary properties of such it follows that

$$\begin{cases} \frac{1}{2}\left[\frac{d}{dn}Q(t^-p) - \frac{d}{dn}Q(t^+p)\right] = P(tp) \\ \frac{1}{2}\left[\frac{d}{dn}Q(t^-p) + \frac{d}{dn}Q(t^+p)\right] = \int h(t\theta)P(\theta p)d\theta = P(tp)/\lambda_0 \end{cases}$$

Adding and subtracting we find for the normal derivative of $Q(qp)$ on either side of the boundary

$$(12) \qquad \begin{cases} \lambda_0\frac{d}{dn}Q(t^-p) = (1+\lambda_0)P(tp) \\ \lambda_0\frac{d}{dn}Q(t^+p) = (1-\lambda_0)P(tp) \end{cases}$$

Regarded, however, as a function of p, Q (qp) is a double stratum potential of moment $\lambda_0 Q(q\theta)$. Hence

$$\begin{cases} \frac{1}{2}[Q(qt^+) - Q(qt^-)] = \lambda_0 Q(qt) \\ \frac{1}{2}[Q(qt^-) + Q(qt^+)] = \lambda_0\int Q(q\theta)h(\theta t)d\theta = Q(qt) \end{cases}$$

Adding and subtracting we have for the values of Q (qp) on either side of the boundary

$$(13) \qquad \begin{cases} Q(qt^+) = (1+\lambda_0)Q(qt) \\ Q(qt^-) = (1-\lambda_0)Q(qt) \end{cases}$$

Similarly P (sp) as a function of p is a double stratum of moment $\lambda_0 P(s\theta)$; and its values on either side of the boundary are found in the same way to be

$$(14) \qquad \begin{cases} P(st^+) = (1+\lambda_0)P(st) \\ P(st^-) = (1-\lambda_0)P(st) \end{cases}$$

From the second of equations (10) $G(qp)$, regarded as a function of q is the sum of potentials $g(qp), -Q(qp)$, and a simple stratum of density $\lambda H(\theta p)$. From the behaviour of these at the boundary, and in virtue of (12), it follows

$$\frac{1}{2}\left[\frac{d}{dn}G(t^-p) - \frac{d}{dn}G(t^+p)\right] = \lambda H(tp) - P(tp)$$

$$\frac{1}{2}\left[\frac{d}{dn}G(t^-p) + \frac{d}{dn}G(t^+p)\right] = \lambda\int h(t\theta)H(\theta p)d\theta + h(tp) - P(tp)/\lambda_0$$
$$= H(tp)$$

Adding and substracting we find

$$(15) \qquad \begin{cases} \frac{d}{dn}G(t^-p) = (1+\lambda)H(tp) - P(tp) \\ \frac{d}{dn}G(t^+p) = (1-\lambda)H(tp) + P(tp) \end{cases}$$

Regarded. however, as a function of p, $G(qp)$ is a double stratum potential of moment $\lambda G(q\theta)$, together with potentials $g(qp)$ and $-Q(qp)$. From the boundary properties of these we deduce

$$(16) \qquad \begin{cases} G(qt^+)=(1+\lambda)G(qt)-\lambda_0 Q(qt) \\ G(qt^-)=(1-\lambda)G(qt)+\lambda_0 Q(qt) \end{cases}$$

Finally $H(sp)$ regarded as a function of p is the sum of potentials $h(sp)$, $-P(sp)/\lambda_0$, and a double stratum of moment $\lambda H(s\theta)$. From which it follows, in virtue of (14) that

$$(17) \qquad \begin{cases} H(st^+)=(1+\lambda)H(st)-P(st) \\ H(st^-)=(1-\lambda)H(st)+P(st) \end{cases}$$

§3.—*Solution regular at a singular parameter value.*—We are now in a position to find solutions to the boundary problems (1), with second members modified, having no singularities for the characteristic number λ_0. If we define the functions $W(p)$ and $V(p)$ by

$$(18) \qquad \begin{cases} W(p)=\int f(\theta)H(\theta p)d\theta \\ V(p)=\int G(p\theta)f(\theta)d\theta \end{cases}$$

we find on substituting the values of $H(\theta p)$ from (8) that $W(p)$ is the sum of potentials of double strata of moments $f(t)$, $-\int f(\theta)P\theta t)d\theta$, and $\lambda\int f(\theta)H(\theta t)d\theta$ respectively.

Hence we find that

$$\begin{aligned} &\tfrac{1}{2}[W(t^+)-W(t^-)]-\tfrac{1}{2}\lambda[W(t^+)+W(t^-)] \\ &=f(t)-\int f(\theta)P(\theta t)d\theta+\lambda\int f(\theta)H(\theta t)\,d\theta \\ &-\lambda\int\{f(\phi)h(\phi t)-\int f(\theta)P(\theta\phi)h(\phi t)d\theta+\lambda\int f(\theta)H(\theta\phi)h(\phi t)d\theta\}d\phi \end{aligned}$$

In virtue of (8) the second member disappears except for the first two terms. So that $W(p)$ satisfies the boundary condition.

$$(19a) \quad \tfrac{1}{2}[W(t^+)-W(t^-)]-\tfrac{1}{2}\lambda[W(t^+)+W(t^-)]=f(t)-\int f(\theta)P(\theta t)d\theta$$

In this all the functions are regular when $\lambda=\lambda_0$; so that this equation admits the solution $W(p)$ which is regular even when λ is put equal to the singular value λ_0. It has been shown elsewhere[1] that for this value of the parameter the first problem (1) does not admit a solution by double stratum unless the condition

$$\int f(\theta)P(\theta t)d\theta=0$$

is satisfied, in which case the solution is obviously $W(p)$.

Similarly substituting the value of $G(p\theta)$ given by (8) we find that $V(p)$ is the sum of potentials of simple strata of densities $f(t)$, $-\int P(t\theta)f(\theta)d\theta$ and $\lambda\int H(t\theta)f(\theta)d\theta$. From the boundary properties of simple strata it follows that

$$\begin{aligned} &\tfrac{1}{2}\Big[\frac{d}{dn}V(t^-)-\frac{d}{dn}V(t^+)\Big]-\tfrac{1}{2}\lambda\Big[\frac{d}{dn}V(t^-)+\frac{d}{dn}V(t^+)\Big] \\ &=f(t)-\int P(t\theta)f(\theta)d\theta+\lambda\int H(t\theta)\,f(\theta)d\theta \\ &-\lambda\int h(t\phi)\,[f(\phi)-\int P(\phi\theta)f(\theta)d\theta+\lambda\int H(\phi\theta)f(\theta)d\theta]d\phi \end{aligned}$$

1 Weatherburn. "Boundary Problems, etc," §6.

In virtue of (7) and (8) the second member reduces to the first two terms; so that $V(p)$ satisfies the boundary problem.

$$(19b)\quad \tfrac{1}{2}\Big[\frac{d}{dn}V(t^-)-\frac{d}{dn}V(t^+)\Big]-\tfrac{1}{2}\lambda\Big[\frac{d}{dn}V(t^-)+\frac{d}{dn}V(t^+)\Big]$$
$$=\mathrm{f}(t)-\int \mathrm{P}(t\theta)\mathrm{f}(\theta)d\theta$$

All the functions involved are regular for the singular value $\lambda=\lambda_0$, so that $V(p)$ is the solution of the problem (19b) regular even when λ is equal to this singular value. The problem (1b) does not admit a solution by simple stratum only, when $\lambda=\lambda_0$, unless the condition

$$\int \mathrm{P}(t\theta)\mathrm{f}(\theta)d\theta=0$$

is satisfied, in which case the required solution is obviously $V(p)$. The problems (19), derived from (1) by altering the second member, we shall speak of as the modified problem for the singular value λ_0. The functions $H(t\mathrm{p})$ and $G(pt)$ bear the same relation to the solution of the modified problems that $\mathrm{H}(tp)$ and $\mathrm{G}(pt)$ bear to the original problems (1).

§4.—*Expansions.*—From the formulæ (8) and (18) we may obtain, by the method of successive approximations, expansions for the various functions in ascending powers of λ. These are certainly true for $|\lambda|<1$, and in particular cases even for $|\lambda|=1$. For the present we shall assume that the absolute value of λ is less than unity.

Thus from (8) in virute of (7) we find

$$(20)\quad \begin{cases} H(ts)=\Big[h(ts)-\dfrac{1}{\lambda_0}\mathrm{P}(ts)\Big]+\lambda\Big[h_1(ts)-\dfrac{1}{\lambda_0^2}\mathrm{P}(ts)\Big] \\ \qquad\qquad +\lambda^2\Big[h_2(ts)-\dfrac{1}{\lambda_0^3}\mathrm{P}(ts)\Big]+\ldots\ldots \\ G(ps)=[g(ps)-\mathrm{Q}(ps)]+\lambda\Big[g_1(ps)-\dfrac{1}{\lambda_0}\mathrm{Q}(ps)\Big] \\ \qquad\qquad +\lambda^2\Big[g_2(ps)-\dfrac{1}{\lambda_0^2}\mathrm{Q}(ps\Big]+\ldots\ldots \end{cases}$$

where the suffixes denote functions formed by successive operations as

$$h_1(ts)=\int h(t\theta)h(\theta s)d\theta,$$
$$h_2(ts)=\int h_1(t\theta)h(\theta s)d\theta,\ \text{etc.}$$

and

$$g_1(ps)=\int g(p\theta)h(\theta s)d\theta,$$
$$g_2(ps)=\int g_1(p\theta)h(\theta s)d\theta,\ \text{etc.}$$

If we extend the notation and replace s by any point p we may write

$$h_1(tp)=\int h(t\theta)h(\theta p)d\theta,$$
$$h_n(tp)=\int h_{n-1}(t\theta)h(\theta p)d\theta,\ \text{etc.}$$

and the first equation (20) becomes

$$(20') \quad \left\{ H(tp) = \left[h(tp) - \frac{1}{\lambda_0} P(tp) \right] + \lambda \left[h_1(tp) - \frac{1}{\lambda_0^2} P(tp) \right] + \ldots \right.$$

Introducing these values in (18) we have, for the solutions of the boundary problems (19)

$$(21) \quad \left\{ \begin{aligned} W(p) &= \int f(\theta) \left\{ \left[h(\theta p) - \frac{1}{\lambda_0} P(\theta p) \right] + \lambda \left[h_1(\theta p) - \frac{1}{\lambda_0^2} P(p\theta) \right] + \ldots \right\} d\theta. \\ V(p) &= \int \left\{ [g(p\theta) - Q(p\theta)] + \lambda \left[g_1(p\theta) - \frac{1}{\lambda_0} Q(p\theta) \right] + \ldots \right\} f(\theta) d\theta. \end{aligned} \right.$$

We may further obtain expansions for the moment $\nu(t)$, and the density $\mu(t)$ of the strata satisfying (19); for these are solutions of the integral equations

$$\left\{ \begin{aligned} \nu(t) - \lambda \int \nu(\theta) h(\theta t) d\theta &= f(t) - \int f(\theta) P(\theta t) d\theta = E(t), \text{ say} \\ \mu(t) - \lambda \int h(t\theta) \mu(\theta) d\theta &= f(t) - \int P(t\theta) f(\theta) d\theta = F(t), \text{ say,} \end{aligned} \right.$$

and are therefore given by the expansions

$$(22) \quad \left\{ \begin{aligned} \nu(t) &= E(t) + \lambda E_1(t) + \lambda^2 E_2(t) + \ldots . \\ \mu(t) &= F(t) + \lambda F_1'(t) + \lambda_2 F_2'(t) + \ldots . \end{aligned} \right.$$

where the successive functions are given by

$$E_1(t) = \int E(\theta) h(\theta t) d\theta$$
$$E_2(t) = \int E_1(\theta) h(\theta t) d\theta, \text{ \&c.}$$

and

$$F_1'(t) = \int h(t\theta) F(\theta) d\theta$$
$$F_2'(t) = \int h(t\theta) F_1'(\theta) d\theta, \text{ \&c.}$$

If we evaluate these functions we find

$$E_n(t) = \int f(\theta) h_{n-1}(\theta t) d\theta - \frac{1}{\lambda_0^n} \int f(\theta) P(\theta t) d\theta$$

$$F_n'(t) = \int h_{n-1}(t\theta) f(\theta) d\theta - \frac{1}{\lambda_0^n} \int P(t\theta) f(\theta) d\theta$$

If now we form double and simple strata with moment and density given by (22) we find exactly the series (21) over again.

§5.—*Formulæ of Reciprocity.*—The Green's function $G(pq)$ admits certain theorems of reciprocity. The argument used to establish these for the ordinary potential[1] is equally valid for the generalised, the symbols having their altered significance. These relations may be stated

i. If the points p and q are both in the same region or both on the boundary

$$(23) \quad G(pq) = G(qp)$$

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1. Plemelj. Loc. cit., S. 395-398.

ii. If p is a point of the inner region, q of the outer, and t a point on the boundary.

$$(24) \qquad \begin{aligned} (1+\lambda)G(pq)&=(1-\lambda)G(qp) \\ G(tp)&=(1+\lambda)G(pt) \\ G(tq)&=(1-\lambda)G(qt) \end{aligned}$$

From (23) and (6) we deduce immediately that if p and q are both in the same region, or both on the boundary,

$$(25) \qquad \begin{cases} Q(pq)=Q(qp) \\ G(pq)=G(qp) \end{cases}$$

If, however, p and q are in the inner and outer regions respectively, we find on substituting from (6) in the first of (24), multiplying by $\lambda_0-\lambda$ and putting $\lambda=\lambda_0$

$$(26) \qquad \begin{cases} (1+\lambda_0)Q(pq)=(1-\lambda_0)Q(qp) \\ (1+\lambda)G(pq)=(1-\lambda)G(qp)+\dfrac{2\lambda_0}{1+\lambda_0}\cdot Q(qp) \end{cases}$$

Similarly from the second and third of (24) we find

$$(27) \qquad \begin{cases} Q(tp)=(1+\lambda_0)Q(pt) \\ Q(tq)=(1-\lambda_0)Q(qt) \end{cases}$$

and thence

$$(28) \qquad \begin{cases} G(tp)=(1+\lambda)G(pt)-\lambda_0 Q(pt) \\ G(tq)=(1-\lambda)G(qt)+\lambda_0 Q(qt) \end{cases}$$

II.—*The ordinary potential.*

§6.—*Integral Relations.*—The preceding properties are common to ordinary and generalised potentials. We know, however, that while the values $\lambda=\pm 1$, which correspond to the problems for the inner and outer regions separately, may both be characteristic numbers for the ordinary potential, they are not[1] singular for the generalised. The properties arising from the existence of these poles are then peculiar to the ordinary potential. Other special relations arise from the fact that for this potential the function $h(tp)$ satisfies the integral relation[2]

$$(29) \qquad \int h(tp)dt=2,\ 1, \text{ or } 0$$

according as p is within the closed surface, on the boundary or outside, and the integration is extended over the boundary. We shall find further on a corresponding formula for the generalised potential from which this may be deduced by putting $k=0$.

Let us suppose that the boundary consists of m independent surfaces each possessing at every point a definite tangent plane and two definite principal radii of curvature. The value $\lambda=1$

1. Weatherburn. Loc. cit., § 3.

2. Plemelj. Loc. cit., S. 341–4. Another proof is by Green's Theorem as in § 9 of this paper.

is always singular. We shall assume that the surfaces are all exterior to one another, so that $\lambda = -1$ is not a characteristic number. The functions $P(ts)$ and $Q(ts)$ assume simple values at the pole $\lambda_0 = 1$. For the functions $\psi_1(s), \psi_2(s), \ldots, \psi_m(s)$ are such that $\psi_r(s)$ is equal[1] to $+1$ over the rth surface and zero over all the other surfaces; while $\phi_r(t)$ is a distribution of electricity over the surfaces giving constant values over each of the surfaces and throughout each of the m inner regions. This distribution $\phi_r(t)$ has a total charge $+1$ over the rth surface, and zero over each of the others. It therefore represents the electric distribution over the m surfaces regarded as conductors, due to unit charge on the rth surface. Hence, if we use an index to denote the particular value of the pole λ_0.

$$P^{+1}(ts) = \phi_r(t) \qquad r = 1, 2, \ldots m$$

according as s is on the 1st, 2nd, mth surface. Further, the function $\psi_r(p)$, being equal to the potential of a double stratum of unit moment over the rth surface, is given by

$$\text{(30)} \qquad \psi_r(p) = \int_r h(tp)dt = 2,\ 1, \text{ or } 0$$

according as p is within the rth surface, on its boundary, or outside that surface. The potential $\Phi_r(q)$ due to the distribution $\phi_r(q)$ is the conductor potential referred to. We shall denote it by $\Gamma_r(q)$. So that

$$\text{(31)} \qquad \begin{cases} P^{+1}(tp) = 2\phi_r(t),\ \phi_r(t), \text{ or } 0 \\ Q^{+1}(qp) = 2\Gamma_r(q),\ \Gamma_r(q), \text{ or } 0 \end{cases}$$

according as p is within the rth surface, on its boundary, or in the outer region. This of course is a particular case of (13) and (14).

We may prove several interesting properties of the functions involved in (5), (7) and (8), making use of the relation (29). If in the first of (7) we replace p by a boundary point s, multiply by dt and integrate over the boundary we find

$$\int P(ts)dt = \lambda_0 \int P(\theta s)d\theta$$

Hence

$$\text{(32)} \qquad \int P(ts)dt = 0 \qquad \lambda_0 \neq 1.$$

By the same process we deduce from (5) that*

$$\text{(33)} \qquad (1-\lambda)\int H(ts)dt = 1$$

Substituting from (6) and putting $\lambda_0 = 1$ we have

$$\text{(33')} \qquad (1-\lambda)\int H^{+1}(ts)dt + \int P^{+1}(ts)dt = 1$$

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1. Plemelj. Loc. cit., Kap. 16.

* In (32) s may be replaced by a point p. The same may be done in (33) and (34') provided the second member be changed to 2 for p in the inner region, and to 0 for p in the outer region. Cf. § 10.

This is an identity in λ, and $P^{+1}(ts)$ does not contain λ. We may therefore put $\lambda = 1$ giving

$$\int P^{+1}(ts)dt = 1$$

which may also be deduced from (31) in virtue of the properties of the distribution $\phi_r(t)$. This last relation combined with (33') shows that

(34) $\int H^{+1}(ts)dt = 0$

while from (32) and (33) it follows that

(34') $(1-\lambda)\int H(ts)dt = 1 \qquad \lambda_0 \neq 1.$

This may also be proved from the first of (8), multiplying by dt and integrating over the boundary.

§7.—*Expansions.*—The second member of the equation (19a) assumes, when $\lambda_0 = 1$, the form

$$E(t) = f(t) - \int f(\theta)\phi_r(\theta)d\theta = f(t) - C_r$$
$$r = 1, 2, \ldots, m$$

according as t is on the 1st, 2nd . . . mth surface.

The series (22a) now becomes, by (29)

(35) $\nu(t) = [f(t) - C_r] + \lambda[f_1(t) - C_r] + \lambda^2[f_2(t) - C_r] + \ldots$

and since $\nu(t)$ now possesses no pole at $\lambda = +1$, while $\lambda = -1$ is not a singular value, this series is convergent for $|\lambda| = 1$. The terms therefore decrease indefinitely, and we have for the constant C_r the value[1]

$$C_r = \mathop{Lt}_{n=\infty} f_n(t)$$
$$= \mathop{Lt}_{n=\infty} \int f(\theta)h_n(\theta t)d\theta$$

where t is on the rth surface. The constant C_r assumes m different constant values, one on each of the surfaces.

In (35) we may put $\lambda = \pm 1$ and thus obtain the moments of the strata, which satisfy respectively the boundary problems.

$$W(t^-) = -[f(t) - C_r]$$
$$W(t^+) = f(t) - C_r$$

The singular value $\lambda = 1$ also corresponds to the second problem for the inner region. The second member of (19b) for this pole takes the form

$$F(t) = f(t) - \int P(t\theta)f(\theta)d\theta$$
$$= f(t) - \phi_r(t)\int f(\theta)d\theta = f(t)$$

provided the usual condition for the inner region, viz.,

$$\int f(\theta)d\theta = 0$$

be satisfied. The function $\mu(t)$ represented by (22b) now becomes

(36) $\mu(t) = f(t) + \lambda f_1'(t) + \lambda^2 f_2'(t) + \ldots$

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1 Cf. Plemelj. Potentialtheoretische Untersuchungen, S. 60.

It has no pole at $\lambda=+1$, while $\lambda=-1$ is not a singular value. The series is therefore convergent for $|\lambda|=1$. In (36) we may put $\lambda=\pm1$ and thus obtain the densities of the simple strata which satisfy respectively the boundary problems

$$\frac{dV}{dn}(t^+)=-f(t)$$

$$\frac{dV}{dn}(t^-)=f(t).$$

The series for the solutions (21) may be obtained from that equation by substituting the values of $P(\theta p)$ and $Q(p\theta)$. Further, if $\lambda_0=1$, the functions $H^{+1}(ts)$ and $G^{+1}(ps)$ given by (20) have no pole at $\lambda=1$, while $\lambda=-1$ is not a singular value. The series are therefore convergent for $|\lambda|=1$, so that the terms decrease indefinitely. It follows that

$$P^{+1}(ts)=\phi_r(t)=\operatorname*{Lt}_{n=\infty} h_n(ts)$$

giving the electric distribution[1], $\phi_r(t)$ in terms of the iterated functions $h_n(ts)$: the limit assuming one of m different values, according to the surface upon which s lies. Similarly from the convergence of the second series (20) for $|\lambda|=1$, it follows that

$$Q^{+1}(ts)=\operatorname*{Lt}_{n=\infty} g_n(ts)$$

i.e.

$$\Gamma_r(t)=\operatorname*{Lt}_{n=\infty} g_n(ts) \tag{37}$$

giving the conductor potential $\Gamma_r(t)$ as the limit of the sequence $g_1(ts)$, $g_2(ts)$, . . . which assumes m different values according to the surface on which s lies.

§8.—*Solution of the second boundary problem for both inner and outer regions in terms of a single function.*—In the second boundary problem the values $\lambda=\pm1$ correspond to the inner and outer regions respectively. The former of these values is the only pole involved. The boundary problem (19b) becomes, for $\lambda_0=1$, and $\lambda=\pm1$ equivalent to the separate problems represented by

$$\begin{cases} \dfrac{dV}{dn}(t^+)=-f(t) & \text{for } \lambda=+1 \\[2ex] \dfrac{dV}{dn}(t^-)=f(t) & \text{for } \lambda=-1 \end{cases} \tag{38}$$

where in the former the boundary function $f(t)$ is subject to the usual integral condition. The solutions to the problems given by (18) may be written

$$V(p)=\int G^{+1}_{+1}(p\theta)f(\theta)d\theta \tag{39}$$

and

$$V(p)=\int G^{+1}_{-1}(p\theta)f(\theta)d\theta$$

[1] Cf. Potentialtheoretische Untersuchungen S. 59.

respectively, where the index represents the pole $\lambda_0 = +1$ and the suffix the particular value of λ. As now the pole $\lambda_0 = +1$ is the only one to be considered we may drop the index in what follows. These two solutions are expressed in terms of different functions $G_{+1}(ps)$ and $G_{-1}(ps)$. It is our object to express both of these in terms of a single function. By means of the second equation (8) we may write

$$(40)\qquad \begin{cases} G_{+1}(ps) - \int G_{+1}(p\theta)h(\theta s)d\theta = g(ps) - \Gamma(p) \\ G_{-1}(ps) + \int G_{-1}(p\theta)h(\theta s)d\theta = g(ps) - \Gamma(p) \end{cases}$$

If we put

$$\begin{cases} 2R(ps) = G_{+1}(ps) + G_{-1}(ps) \\ 2R_1(ps) = G_{+1}(ps) - G_{-1}(ps) \end{cases}$$

we obtain from the preceding by adding and subtracting

$$(41)\qquad \begin{cases} R(ps) - \int R_1(p\theta)h(\theta s)d\theta = g(ps) - \Gamma(p) \\ R_1(ps) - \int R(p\theta)h(\theta s)d\theta = 0 \end{cases}$$

This last equation expresses $R_1(ps)$ in terms of $R(ps)$; hence we may determine both $G_{+1}(ps)$ and $G_{-1}(ps)$ in terms of the single function $R(ps)$. From (41) we find that $R(ps)$ satisfies the integral equation

$$R(ps) - \int R(p\theta)h_1(\theta s)d\theta = g(ps) - \Gamma(p).$$

As in §4, by the method of successive approximations, this integral equation gives us an expansion for $R(ps)$ and hence for $R_1(ps)$. We find

$$\begin{cases} R(ps) = [g(ps) - \Gamma(p)] + [g_2(ps) - \Gamma(p)] + [g_4(ps) - \Gamma(p)] + \ldots \\ R_1(ps) = [g_1(ps) - \Gamma(p)] + [g_3(ps) - \Gamma(p)] + \ldots \end{cases}$$

which are both convergent, being identical with those obtained by adding and subtracting the absolutely convergent series for $G_{+1}(ps)$ and $G_{-1}(ps)$.

The solutions of the second boundary problem for both the inner and the outer regions could also be expressed in terms of the function $K(ts)$ introduced by Plemelj.[1] For from (8) we find

$$G^{+1}(ps) - \lambda\int g(p\theta)H^{+1}(\theta s)d\theta = g(ps) - \Gamma(p)$$

In this we may put $\lambda = \pm 1$ in turn, and thus obtain $G_{+1}(ps)$ and $G_{-1}(ps)$ in terms of $H_{+1}(ts)$ and $H_{-1}(ts)$ respectively, and hence in terms of $K(ts)$. Introducing the values of the functions we find

$$\begin{aligned} G_{+1}(ps) &= g(ps) - \Gamma(p) + \int g(p\theta)\{K(\theta s) + \int h(\theta\sigma)K(\sigma s)d\sigma\}d\theta \\ &= g(ps) - \Gamma(p) + \int g(p\theta)K(\theta s)d\theta + \int g_1(p\theta)K(\theta s)d\theta \end{aligned}$$

Similarly

$$G_{-1}(ps) = g(ps) - \Gamma(p) - \int g(p\theta)K(\theta s)d\theta + \int g_1(p\theta)K(\theta s)d\theta$$

So that the solutions for both regions may be expressed in terms of $K(ts)$.

1. Potent. Unter. S. 79.

III.—*The generalised potential.*

§9.—*Fundamental formula.*—The simple forms taken by the integrals of §6 depend upon the formula (29), which is true only for the ordinary potential. I now propose to find the value of the integral

$$\int h(tp)dt$$

when the potential is generalised, corresponding to the equation (2). In Green's formula

$$(42)\qquad \int\left(\frac{dU}{dx}\cdot\frac{dV}{dx}+\ldots\right)dq=-\int U\frac{dV}{dn}ds-\int U.\nabla^2V.dq$$

put $U=1$, and $V=g(qp)$, q being a variable point and p a fixed point. If in (42) the integration is extended over a closed surface and p is outside the surface we find, since $g(qp)$ satisfies (2)

$$(43)\qquad \int h(tp)dt=-k^2\int g(qp)dq$$

where dq is the element of volume at q. The integration in the second member being extended throughout the volume enclosed by the surface, the integral represents the potential at p due to a uniform distribution of mass of unit density throughout that volume. We shall denote this potential by $X(p)$.

If, however, p is inside the closed surface we must surround p by a small sphere Ω of radius r, the surface integration of (42) now including the surface of this sphere, and the volume integration extending only throughout the volume between the sphere and the original surface. At the small sphere the positive direction of the normal is that of r increasing, so that (42) becomes

$$\int h(tp)dt+k^2\int(gp)dq=-\int_\Omega\frac{d}{dr}g(sp)ds=1/2\pi\int_\Omega e^{-kr}\left(\frac{k}{r}+\frac{1}{r^2}\right)ds$$

and when the radius of the sphere becomes vanishingly small the second member is equal to 2. Hence when p is within the closed surface

$$(44)\qquad \int h(tp)dt=2-k^2\int g(qp)dq=2-k^2X(p)$$

the volume integral of the second member being convergent[1] since the subject of integration becomes infinite at $p=q$ only as $1/r$.

To find the value of $\int h(ts)dt$ where s is a point on the boundary we observe that $\int h(tp)dt$ is a double stratum potential of unit moment over the boundary. Hence its value at a point on the surface is the mean of its values at points infinitesimally close to this, one just inside and the other just outside. So that

$$(45)\qquad \begin{aligned}\int h(ts)dt&=1-k^2\int g(qs)dq\\&=1-k^2X(s)\end{aligned}$$

1 Cf. Leathem. "Volume and surface integrals used in Physics," p. 14 (Cambridge Tract, 1905).

§10.—*Further relations.*—By means of the preceding results we may obtain relations corresponding to those of §6 for the ordinary potential. From the first equation (7) we find on multiplying by dt and integrating over the boundary,

$$\int P(tp)dt=\lambda_0\int[1-k^2X(\theta)]P(\theta p)d\theta$$

that is,

$$(1-\lambda_0)\int P(tp)dt=-k^2\lambda_0\int X(\theta)P(\theta p)d\theta \tag{46}$$

which reduces to (32) when k^2 is put equal to zero. Similarly from the first of (8) we find on integration with respect to t

$$\lambda\int[1-k^2X(\theta)]H(\theta p)d\theta=\int H(tp)dt-c+k^2X(p)-\frac{1}{\lambda_0}\int P(tp)dt$$

or

$$(1-\lambda)\int H(tp)dt=c-k^2X(p)-\lambda k^2\int X(\theta)H(\theta p)d\theta+\frac{k^2}{1-\lambda_0}\cdot\int X(\theta)P(\theta p)d\theta \tag{47}$$

where c has the value 2, 1, or 0, according as p is within the inner region, on the boundary, or in the outer region. This relation reduces to (33) when k is zero and p on the boundary.

These might have been derived from (5), the first of which becomes on integration

$$(1-\lambda)\int H(tp)dt=c-k^2X(p)-\lambda k^2\int X(\theta)H(\theta p)d\theta \tag{48}$$

Substituting from (6), multiplying by $(\lambda_0-\lambda)$ and proceeding to the limit $\lambda=\lambda_0$ we arrive at (46). Then substituting from this in (48) we find (47).

The preceding investigation deals with the singular parameter values of the first two boundary problems only. In another paper[1] the author considers the third boundary problem for the equation (2), requiring the determination of a solution satisfying the relation

$$\frac{dV}{dn}(t^+)=\lambda\beta(t)V(t^+)-\beta(t)U(t)$$

The singular parameter values for this problem are there discussed.

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1 Weatherburn. "The mixed boundary problem for the generalised potential corresponding to the equation $\nabla^2 u-k^2u=0$." Quarterly Journal, vol. 46, pp. 88-94.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART II., 1914.]

ART. XIV.—*On the Geographical Distribution of the Sea-Grasses.*

A PRELIMINARY COMMUNICATION.

BY C. H. OSTENFELD
(Copenhagen, Denmark).

Communicated by Professor A. J. Ewart.

[Read October 8th, 1914.]

I.

For several years I have been studying the geographical distribution of the *Marine Flowering Plants*, as it seemed to me that it might have some general value both from a phylogenetic and a geological point of view.

We owe most of our knowledge on these plants to the late P. Ascherson, who, during a series of years, contributed to their study, and was much interested in their geographical distribution.

Some considerations will show why I think this phytogeographical study may be of more general interest.

The marine flowering plants—or *sea-grasses*—belong to two monocotyledonous families—viz., *Hydrocharitaceae* and *Potamogetonaceae*, both of which are included in the cohort *Helobieae*. This cohort consists of several families, nearly all of which are water-plants (or swamp-plants). They are very distinct from the other monocotyledons, and undoubtedly represent old types.

Sometimes it has been urged that from this cohort most of the other Monocotyledons and Dicotyledons have originated. Be that as it may, the Helobieae form an especially well-marked group within which the families show a progression from types with many free superior carpels to others with one syncarpous inferior ovary. In all the families, genera with one or a few species prevail, and within the whole cohort only one genus, *Potamogeton* (the Pondweed), is really rich in species. It seems as if, in most cases, the developing power of the genera has been checked.

The *sea-grasses* belong to—

(1.) 3 genera of *Hydrocharitaceae*—viz.: *Halophila*, *Enhalus* and *Thalassia*, all widely different from one another; and to

(2) 5 genera of *Potamogetonaceae*—viz.: *Cymodocea*, *Diplanthera*, *Posidonia*, *Zostera*, and *Phyllospadix*. The two first and the two last respectively are closely related to each other. Thus it might be possible to classify these 5 genera also into three groups, each group widely differing from the others.

The systematic position of the sea-grasses, their aquatic habitat, and the great structural differences between the genera, all point to their great phylogenetic age.

The natural agent of dispersal of the sea-grasses is the sea currents, as the fruits in no case ripen above the water. The *Potamogetonaceae* have droupe-like fruits, the epicarp of which is a rather thin, fleshy cover of inconspicuous colour. The *Hydrocharitaceae* have a berry, also of inconspicuous colour, containing either many small seeds (*Halophila*), or a few large ones (*Enhalus* and *Thalassia*). In *Zostera* (of the Potamogetonaceae) the epicarp, but in *Enhalus* and *Thalassia* the whole pericarp splits open, and in all the genera the "stones," or seeds, then drop out. As the fruits or seeds of the sea-grasses do not possess a floating apparatus, they are always heavier than water, and consequently the migration of the species must be very slow.

Besides this transportation by means of currents, it is possible—but not very probable—that certain fishes, and sea-mammals, such as the Dugong and Manatee, and turtles, may eat the fruits and thereby contribute to their distribution.

The dispersal by means of detached shoots, which float in the water, is almost negligible, as they do not live long when floating.

Being green autotrophous plants, the sea-grasses can grow only in shallow water where the light is sufficient for assimilation —*i.e.*, they grow only along the coasts. The depth at which they grow varies in the different species and in different seas. In northern seas (*e.g.*, *Danish*), the deeper limits of *Zostera* lie at about 10 meters. In the Mediterranean, *Posidonia* grows at greater depths, though I cannot accept without further evidence the record of its occurrence at a depth of about 50 meters.

The slow manner of dispersal and the necessity of shallow water are factors which restrict the area of occurrence of the sea-grasses. Of the 8 genera mentioned above, *Enhalus* is monotypic. It occurs in the whole of the tropical Indopacific region. The *Zostera* genus consists of two or more species.

With the exception of *Phyllospadix*, a younger type derived from *Zostera*, and restricted to the northern Pacific, each genus inhabits

both the Indopacific and the Atlantic regions. And, as nearly all are tropical, sub-tropical, or warm-temperate plants (*Zostera* being the only one which reaches the cold regions), the occurrence of the same genus in both regions indicates that the genera are so old that they originated at a time when the distribution of sea and land was very different from that at present—this time being at least not later than Early Tertiary.[1] It is not probable that such heat-requiring plants could have migrated from the Indopacific, where they most probably originated, into the Atlantic, through the cold waters either around the Cape of Good Hope or Cape Horn.

Thus their distribution seems to indicate the great age of the sea-grasses, as does their low place in the natural system of the Phanerogams.

Hence it will, I think, be obvious that a detailed study of the geographical distribution, bearing in mind their systematic affinities, may possibly throw some light on the evolution of the sea-grasses, on the distribution of sea and land, and on the age of the present land-bridges or land-barriers separating the oceans.

The 8 genera of sea-grasses contain altogether only 30 species, most of them having a wide distribution, as is often the case with water plants.

It will be convenient to arrange them into several groups according to their geographical distribution, instead of treating each species separately.

I.—*Indopacific group* (7 species), *i.e.*, species which grow in the Red Sea, along the coasts of East Africa and of the East-African Isles, along the south and south-eastern coasts of Asia, in the Malay Archipelago, the islands of the Pacific, and, in some cases, also on the tropical coast of Australia.

II.—*Malayan group* (4 species), *i.e.*, species found in the Malayan region: south-eastern coast of Asia, Malay Archipelago, and the tropical coast of Australia.

III.—*East-African group* (2 species), *i.e.*, species found only in the Red Sea, along the coasts of East-Africa and of the East-African isles.

IV.—*Caribbean group* (6 species), *i.e.*, species occurring along the coasts of the islands of the Caribbean Sea, Florida, and the north-coast of South America, some extending as far as the Bermudas.

1. Some, e.g. *Posidonia*, perhaps even Upper Cretaceous.

V.—*Australian group* (5 species), *i.e.*, species found along the western and southern coasts of Australia and all round Tasmania, some extending as far as Queensland and New Zealand.

VI.—*Mediterranean group* (2 species), *i.e.*, species occurring in the Mediterranean and reaching the Atlantic coasts at the mouth of the Mediterranean.

VII.—*North-Pacific group* (2 species), *i.e.*, species occurring along the North-Pacific coasts of North America, and (one species) also along the coasts of Japan.

VIII.—*North-temperate group* (2 species), *i.e.*, species occurring in the northern (cold and temperate) parts of both the Atlantic and the Pacific oceans.

Of these eight groups, I.-IV. are *tropical*, V.-VI. *warm-temperate* (or subtropical), and VII.-VIII. *temperate*.

I. The *Indopacific group* consists of 7 species—viz.: Halophila ovalis; Enhalus acoroides; Thalassia Hemprichii; Cymodocea isoetifolia; Cymodocea rotundata; Cymodocea serrulata; Diplanthera uninervis.

Halophila ovalis has the widest area of distribution, as it reaches the western and southern coasts of Australia. Taken as a whole, the geographical area of this group is larger than that of any other (perhaps except that of *Zostera marina*). It is probable that the group represents the direct offspring of the old types of sea-grasses and that it inhabits their old area.

II. The *Malayan group* has four species, viz.: Halophila decipiens, Halophila ovata, Halophila Beccarii, Halophila spinulosa. All these species are rare, being found only in a few places, but it is probable that further search will show that they have a wider distribution, so that the group may perhaps be included in the Indopacific one.

[It is worth noting that *H. spinulosa* differs widely from all other species of *Halophila*, and is probably of great age. Being of quite characteristic habit, and also comparatively conspicuous, it is not probable that it has been overlooked on the continental coasts of the Indian Ocean, from which it has not yet been reported; it seems, in fact, to be restricted to the Malay region.]

III. The *East-African group* has only two members—viz.: Halophila stipulacea, Cymodocea ciliata. They are confined to the Red Sea and the western side of the Indian Ocean. (*C. ciliata* has been reported from Australia in error for *C. serrulata*.)

The two groups, II. and III., are naturally placed as subdivisions of group I., and represent two lines of differentiation from the main body of species, with its wider distribution. They show species, which have not yet attained their limits of distribution, as it seems hard to understand that a species distributed along the shores of the Red Sea and the western side of the Indian Ocean, should not be able to live along the Asiatic and Malay coasts, and *vice versa.* The absence of *Halophila spinulosa* from the Indian Ocean, and that of *H. stipulacea* and *Cymodocea ciliata* from the Malay Archipelago, are further indicative of the slow rate of migration of the sea-grasses. These well characterised species must have existed as such for a long time, probably as long as a connection between the Indian and the Pacific oceans existed.

IV. *The Caribbean group.*

Halophila Aschersonii.
Halophila Engelmanii.
Halophila Baillonis.
Cymodocea manatorum.
Diplanthera Wrightii.
Thalassia testudinum.

This group contains 4 genera with 6 species. Four of these (one of each genus—are so nearly related to 4 species of the Indopacific group, that—at least, in some cases—the characters distinguishing them from one another are quite slight.

The 4 pairs of species are the following :—

Indopacific :
Halophila decipiens.
Thalassia Hemprichii.
Cymodocea isoetifolia.
Diplanthera uninervis

Caribbean :
Halophila Baillonis.
Thalassia testudinum.
Cymodocea manatorum.
Diplanthera Wrightii.

I think it is advisable to draw the conclusion that these 4 pairs originated from 4 parent species, which were widely distributed in the tropical seas, and that the present differentiation was subsequent to an alteration in the extension of sea and land—in other words: the Caribbean species arose in their present area from ancestors which came to the Caribbean Sea from the Indopacific

at a time when the isthmus of Panama was not finally formed. From geological evidence, it is usually agreed that the isthmus is of Tertiary age, and the differentiation of the Caribbean species is consequently more recent. The close resemblance of each species to an Indopacific one agrees very well with this supposition. Their restricted geographical areas may be similarly explained.

Two of them have reached the Bermudas, and this migration accords with the direction of the Gulf Stream drift, which has a very strong flow from the coast of Florida towards the north-west, washing on its way the shores of the Bermudas. With this exception, none of the Caribbean species has yet become distributed in the Atlantic outside the Caribbean region. Although it may be admitted that our knowledge of the sea-coast flora of South America is imperfect, it is hardly likely that any rich sea-grass vegetation, if existing, could have remained unreported.[1]

Besides the 4 Caribbean species having their Indopacific partners, two species of *Halophila* also occur in the Caribbean region, one in the northern part (Florida and Bahamas), and the other in the southern parts (Antilles to Pernambuco). They are very closely allied, and must have come from a common ancestor. On the other hand, they are quite distinct from other species of *Halophila*, and no allied species has yet been found in the Indopacific region. It is possible that such a form may yet be found, but it is also possible that it has had its day and then died out there, and that the Caribbean forms are the only remnants now existing of this particular section of the genus.

V. *The Australian group.* I have referred 5 species to this group, but it is not so homogeneous as I could wish:

Cymodocea antarctica.
Posidonia australis.
Zostera capricorni.
Zostera Muelleri.
Zostera tasmanica.

The systematic value of the three species of *Zostera* is somewhat uncertain. It is possible that they ought to be reduced to two, and even one of these might perhaps be united with *Z. nana*. Their area of occurrence is along the east coast of Australia, from Cape York southwards to Tasmania, and along the eastern part of the

1. Amongst the sea-grasses on record from the African side of the Atlantic, there is a sterile species of *Diplanthera*, found at Loanda (Guinea). Whether it is the Caribbean *D. Wrightii* or, more probably, the Indopacific *D. uninervis*, already recorded from the East-coast of Africa, it is impossible to say.

south coast (how far westwards I do not know); also in New Zealand and in one place on the coast of Chili. Thus the area covers the temperate part of the South-Pacific, with an outpost in the Tropics at Cape York.

The discussion of the origin of this part of the Australian group will be postponed and taken together with that of other species of *Zostera*.

The other section of the Australian group consists of two species. The first—*Cymodocea antarctica*—stands somewhat isolated within the genus. It is quite different from its nearest ally, the East-African *C. ciliata*, and it must be supposed to be an old species. The other—*Posidonia australis*—has only one congeneric species, *P. oceanica*, of the Mediterranean. Thus, these two species, which make up the isolated genus *Posidonia*, inhabit widely separated and comparatively small areas of a warm-temperate character.

The species are quite distinguishable from one another, in good agreement with their remote areas of occurrence.

The marked specific differences, as well as the isolated place of the genus within the Potamogetonaceae, indicate their great age. The following more detailed explanation of their distribution is only a working hypothesis. In former times the genus inhabited a continuous area, of which the present two isolated areas are the only remnants. It seems as if the genus is now no longer fit for true tropical conditions, while the ancestors of the present species did occur in the Tropics. Tropical conditions, then, have driven *Posidonia* towards the north and south; and the Australian south-coast and the Mediterranean are the last refuge for a dying genus, which, to judge from identifications of leaves from Tertiary and Cretaceous times, is one of the oldest flowering plants.

VI. *The Mediterranean group* contains only two species—viz.:

Cymodocea nodosa.

Posidonia oceanica.

The two species, *Zostera marina* and *Z. nana* also occur in the Mediterranean, but are not restricted to it.

We have already dealt with *Posidonia oceanica*, when treating of the Australian *P. australis*. Neither *Posidonia* nor *Cymodocea* goes into the Black Sea, probably because its waters are neither warm nor saline enough; *Zostera marina* and *Z. nana*, on the other hand, having greater ability of adaptation, penetrate into the Black Sea.

Posidonia and *Cymodocea* have migrated through the Straits of Gibraltar out along the nearest Atlantic coast, *Posidonia* going northwards along the Iberian peninsula as far as the head of the Bay of Biscay, and *Cymodocea* northwards to Cadiz and southwards along the African coast to Senegambia and the Canaries. These interesting extensions of distribution are slight, and the two species are essentially Mediterranean in type.

As explained above, *Posidonia* has its only allied species in Australian waters. *Cymodocea nodosa* is nearest allied to *C. rotundata*, one of the Indopacific species. Therefore it seems justifiable to consider the Mediterranean species as derived from the Indopacific one; or, perhaps more correctly, to derive both from an Indopacific ancestor. The main point, however, is that both *Posidonia* and *Cymodocea* must be supposed to have come to the Mediterranean from the Indopacific region, and that this happened at a comparative early time, since the two Mediterranean species have developed so far along their own line of evolution, and are now specifically well characterised.

On the other hand, *Zostera marina* and *Z. nana* came into the Mediterranean from the north and west, through the Straits of Gibraltar.

VII. *The North-Pacific group* consists of the genus *Phyllospadix*, with its two very closely allied species—viz.: *Phyllospadix Scouleri* and *P. Torreyi*.

The genus *Phyllospadix* has arisen from *Zostera*. It differs in being dioecious and having a short, contracted rhizome (not the long, straggling rhizome of *Zostera*). The two species are so close together, that an American botanist, W. K. *Dudley*, who has studied them in situ, doubts if they are really distinct. The one (*P. Scouleri*) is very variable, while the other (*P. Torreyi*) is not, and the amplitude of the variation of the first species includes that of the second one. Both species inhabit the same part of the west coast of North America, from southern California to British Columbia; and the variable (probably older) species occurs in Japan, also making it probable that it, too, may be found in the intermediate region, along the shores of the Aleutian islands and the south coast of Alaska.

The genus being restricted to the northern Pacific, and derived from *Zostera*, has probably originated not in the tropics, but in its present home, and at a comparatively late time.

Phyllospadix serrulatus Rupr., of doubtful standing, came from Alaska.

VIII. *The North-Temperate group:*
Zostera marina and Zostera nana.

This group has really only one typical representative—viz.: *Z. marina*, but the other wide-spread species, *Z. nana*, comes perhaps also best in here, as an irregular member. Its distribution, together with that of the Australian *Zosteras*, gives, I think, the key to the evolution of the genus.

Zostera is a very much reduced type, which is supposed to have come from *Potamogeton*- and *Ruppia*-like ancestors. The flowering axis bears flowers on one side only, and the flowers are naked; but on the outer side of each flower we find a scale—the so-called *retinaculum*. This scale is sometimes supposed to be a reduced perianth. It is present in *Zostera nana*, and apparently also in the Australian species, while wanting—ordinarily—in *Z. marina*. Its presence in *Z. nana*, and allied species, seems to indicate that they are the older types, and *Z. marina* the younger. The distribution of *Z. nana* and of its allies strengthens this view. *Z. nana* is known along the coasts of Europe, from Southern Scandinavia southwards into the Mediterranean, where it penetrates into the Black Sea; further, it is found on the Atlantic coast of Morocco and in the Canaries. It does not occur along the tropical west-coast of Africa, but re-appears in South Africa and in Madagascar. It is reported with doubt from the Seychelles also. Lastly, we have records of it from Tonkin and Japan. Now it must be admitted that the identity of the plants from all these regions is not certain, as it is known, with flowers and fruits, from Europe only, and the vegetative organs show no specific distinctions.

Owing to the uncertainty of some of the records, I find it better to err on the side of caution, and to make the more general statement:—that a narrow-leaved and small *Zostera* has been found in the above-mentioned areas. I would associate with this form the closely-allied three Australian species, the distribution of which I have already given. In this way we get one group of narrow-leaved and small Zosteras, with an almost word-wide distribution. It is worth noting that this group is absent from both coasts of North America, and that the records are very scanty as regards tropical localities. The distribution has some resemblance to that of the genus *Posidonia*, but it is less restricted. And I think the same explanation holds good here—viz.: the Zostera group originated in the Tropics, and migrated both northwards and southwards, nearly disappearing in its original home. Mean-

while the extinction in the Tropics of *Zostera* has not been as complete, as is the case with Posidonia; and *Zostera* does not show such marked signs of waning as it does.

The younger type of the genus, *Z. marina*, is distributed along the coasts of Europe, from the Black Sea and the Mediterranean in the south to Lapland (Murman coast) in the north. From the British Isles it has reached the Faeroes and Iceland; and it is also found at one locality on the western side of Greenland. But its occurrence here is, I think, due to accidental transport by man, as it is near places inhabited, onwards to the present time, from the time of the old Norse colonists.[1] Along the Atlantic coast of America we find *Z. marina*, extending from the Gulf of St. Lawrence to Virginia. Quite separated from its Atlantic area is the North Pacific one, which on the American side extends from Southern California to Alaska, while the Asiatic side includes the coasts of Manchuria and Japan.

Z. marina is thus distributed along all the coasts of the North Atlantic and the North Pacific, but it is wanting in the intermediate area, the Arctic Ocean (with the above-mentioned exception of Greenland). The question now naturally arises: How has it come to have this discontinuous distribution? The possibility that it originated during a warmer climate in the Arctic sea, and was driven southwards by a deterioration of the climate, is hardly probable.

The origin of the genus was supposed to be tropical, and it is more probable than *Z. marina* also, which is by no means young, in spite of being younger than the *Z. nana* group, originated in a warm ocean and migrated northwards; but the evidence is not sufficiently clear whether this home was the Pacific or the Atlantic. As it is not probable that the one species originated in both oceans, a migration from one ocean to the other seems necessary. We have then two ways of migration: (1) Either it migrated through a sea-connection which does not now exist—*e.g.*, through the Caribbean connection (just as it is probable that the Caribbean group of sea-grasses did); (2) or, it migrated by way of the Arctic ocean at a time when its waters were warm. The latter way of migration seems more probable from a biological point of view, and is better in accord with the present-day conditions life of the species.

Much of what has ben said here about the evolution of the sea-grasses and their migrations is, of course, only hypothetical, and

may be wrong. Still, it seems to me that the existing facts of the distribution of the genera and species make deductions of that kind allowable. They are a help in gaining an idea of how these interesting remnants of the older types of Flowering Plants attained their present areas of distribution.

The peculiarities of distribution of the sea-grasses are not without parallel. Amongst the Marine Algae similar cases have been reported. *George Murray* (1873) has pointed out that there is a great resemblance between the algal flora of the Caribbean Sea and that of the Indopacific region. He supposes it to be explicable by a migration by way of the Cape. *N. Svedelius* (1906) agrees with Murray as to the great resemblance of the floras, which he has himself studied, especially in *Canlerpa* (surely a very old type); but his explanation necessitates a water-connection where the Isthmus of Panama now is. This is essentially the same explanation as that I have offered with regard to the origin of the Caribbean sea-grasses.

III. *Summary.*

1. The Marine Flowering plants, the *sea-grasses*, belong to two families of the old monocotyledonous cohort, the *Helobieae.* They are reduced and specially adapted ancient types.

2. With one exception (the monotypic *Enhalus*), the genera all occur in the Indopacific and the Atlantic regions. This distribution indicates that the origin of the genera goes back to a time when the relation of sea and land was different from that now—viz. to the earlier part of the Tertiary period.

3. The dispersal of the sea-grasses is restricted and slow. It is mainly due to sea-currents, but the seeds are not able to float, and detached pieces of rhizomes do not live long.

4. The 8 genera contain altogether only 30 species, which can be arranged into 8 groups, according to their geographical distribution—viz.: (a) 4 *Tropical:* Indopacific, Malayan, East-African and Caribbean; (b) 2 *Warm-temperate* (or sub-tropical): Australian, Mediterranean; and (c) 2 *Temperate:* North-Pacific and North-Temperate..

5. The Indopacific group contains the majority of the species, especially when we include the Malayan and East-African groups as sub-divisions (13 species). The parent home of the sea-grasses lies within the geographical area of this group.

6. The Caribbean group (6 species) has 4 species, each of which is closely allied to an Indopacific one, and it is probable that the

whole group migrated from the Indopacific to the Caribbean Sea at a time when there was a connection between them through the Isthmus of Panama. Two of these species have reached the Bermudas, but elsewhere they are not found outside the Caribbean region, the Atlantic Ocean being very poor in sea-grasses.

7. The genus *Posidonia* has at the present time one species along the south coast of Australia, and the other in the Mediterranean. It is supposed that they represent the last remnants of a genus whose home was somewhere in the Indian region, and that it was driven away towards the north and the south.

8. The other species of the Mediterranean group, *Cymodocea nodosa*, also migrated from the south-east into the Mediterranean, while the two Zosteras of this sea came from the north.

9. The genus *Phyllospadix* is restricted to the North Pacific. Its morphological characters indicate its derivation from Zostera.

10. The narrow-leaved, small *Zosteras* (*Z. nana*, and the three Australian species) are supposed to be the older type of the genus, as they still have the "retinaculum" (the scale attached to the flower). When taken together, their distribution is "bipolar," with a few outposts in the Tropics.

11. It is supposed that the genus *Zostera* originated in a warm sea and migrated towards the north and the south.

12. The younger type, *Zostera marina*, is yet an old species. It is supposed that it also originated in a warm sea (perhaps in the Indopacific region), wandered northwards, and in one manner or another came from the Pacific into the Atlantic, or *vice versa*.

13. With the exception of *Phyllospadix*, which originated in the North-Pacific, and arose from *Zostera*, all the genera of sea-grasses are supposed to have arisen in the Tropics, where the home of most of them still is, *Zostera marina* being the only species which extends into the Arctic Sea.

14. The distribution of the species still requires investigation. This applies especially to the three Australian *Zosteras*, which are little known, both systematically and geographically.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PT. II., 1914].

ART. XV.—*Bitter Pit and Sensitivity of Apples to Poisons.*

An Answer to Prof. A. J. Ewart.

BY

H. G. BREIDAHL, B.Sc.

AND

A. C. H. ROTHERA, M.A., D.Sc.

[Read 8th October, 1914].

This opportunity has kindly been given us of replying to a paper by Prof. A. J. Ewart, appearing in the Proceedings of this Society, Vol. XXVI., p. 228, March, 1914, in which he criticises a paper by R. H. Greenwood and A. C. H. Rothera, forming portion of the Second Progress Report, issued by Mr. D. McAlpine.

The position briefly is this:

A theory that Bitter Pit might be due to poisoning of certain cell groups in the apple was put forward by Dr. Jean White, and strenuously supported by Prof. Ewart. This theory included the statement that the apple cells of the areas affected with pit have their diastatic enzymes destroyed—or inhibited—by the poison before the cells themselves are killed. It is logical, if this be so, to attempt to show that bitter pit tissue contains some poison capable of inhibiting diastatic action, and Greenwood and Rothera searched first for such a poison in a soluble form, second in an insoluble form. They were unable to get any evidence of inhibition, their results either showing no effect, or in the case of malt diastase an acceleration with both normal pulp and pitted material. This acceleration was assigned to the beneficial effect which traces of organic acids exert upon malt diastase, which explanation is still held to be the correct one for this result, since it naturally accounts for the slightly greater acceleration produced by healthy pulp cells than by bitter pit, and also for the greater retardation of ptyalin (which is injured by slight acidity), by the former than the latter.

Against these experimental results Prof. Ewart raises various criticisms.

His first is a complete denial. He writes: "On repeating these experiments with filtered solutions of malt diastase dissolved in distilled water, I am able to give them emphatic contradiction. Prolonged contact with pounded apple pulp, boiled or unboiled,

bitter pit, or normal, practically destroys diastase in one to three days."

But in the next paragraph it appears that 20 grms. of pounded pulp were added to only 10 c.c. of 1% *Taka* diastase. No experiments are quoted which are comparable with Greenwood and Rothera's, in which 1 grm. of pounded pulp was used with 5 c.c. of a 5% *malt* diastase, and the emphatic contradiction is therefore most unjustifiable.

The second criticism is that the observed accelerating action on malt diastase was not an acceleration, but only an apparent acceleration, due to an experimental pitfall.

Owing to actions of tannic acid on starch solutions causing precipitation of the starch, and also to the influence of tannic acid upon the starch iodine test employed, Greenwood and Rothera are assumed to have been misled into taking the digestion of the starch as complete, when it really was still incomplete.

Though convinced that a real acceleration of malt diastase had been obtained with both normal apple tissue and bitter pit material, and that the experimental technique employed excluded the pitfalls suggested by Prof. Ewart, it was decided to carefully investigate the criticism raised as to the action of tannic acid.

Freely acknowledging full indebtedness to Professor Ewart for bringing the tannic acid complications to our notice, we find that such complications cannot be applied to refute the experimental results of Greenwood and Rothera.

In the first place, though the blue colour produced by starch with a small amount of iodine can be destroyed by tannic acid, the proportions of the reagents are quite different to those of the experiments of Greenwood and Rothera, in which the maximum tannic acid could not exceed .002% final concentration, and in which the iodine was always used in large excess.

For, in following a starch digestion, it is customary to remove 1 drop of the starch solution, which is then mixed with 1 drop of a 1% iodine solution, and the blue colour produced under such conditions is uninfluenced by tannic acid in concentrations up to 1%.

Only when the quantity of tannic acid is large, and the iodine very little in amount, does the decolourising power of the tannic acid become important.

Then again, we find that Ewart is unfortunate in his second point that tannic acid inhibits diastatic action by forming a compound with starch which is resistant to the ferment.

Although tannic acid (in the concentrations with which we are concerned, when dealing with apple tissue or juice) does produce a slight cloudiness in a 1% filtered starch solution, this does not render the starch any less readily digested by diastase. With the weaker tannic acid solutions (as Prof. Ewart points out) the cloudiness vanishes at 35° C.

In fact, with the taka diastase (Merck) in the possession of the laboratory, the presence of small amounts of tannic acid caused an acceleration of the enzyme action, and a slowing was only obtained when the tannic acid concentration was approximately five times as great as in apple juice.

It proved a most fortunate circumstance for us that the taka diastase preparation in our possession (the same as that used by Greenwood and Rothera) showed this acceleration, for it permitted us to show that (at least for the tannic acid concentrations up to .25%) tannic acid does not form a starch compound of less digestibility, and that where it does inhibit diastatic action it does so by precipitating the enzyme as suggested by Payen.[1]

Solutions of the taka diastase in our possession gave no immediate precipitate with dilute tannic acid, but in some of our experiments, in which a weak enzyme solution was used, a precipitate did form after two hours, and was accompanied by a slowing of the rate of action.

This slowing apparently depended upon the flocculation of the enzyme *per se*, and was not proportional to the amount of tannic acid present. In fact, a slightly greater amount of tannic acid produced less slowing, probably because the accelerating factor was present simultaneously.

Careful tests were made in order to be certain that the tannic acid acceleration was not due to an influence exerted upon the starch-iodine colour.

Greenwood and Rothera used strong solutions of taka diastase, and in the light of present results the very small amount of tannic acid extracted from healthy apple pulp, or pitted cells, could only have had a slight accelerating influence.

With the malt diastase (Merck) (the same preparation as that used by Greenwood and Rothera) tannic acid solutions, even when dilute, always gave a precipitate, with solutions of the enzyme, accompanied by a retardation of action. In Greenwood and Rothera's experiments with malt diastase, accelerations were

1. Quoted from Czapec Biochemie der Pflanzen, vol. i., p. 345.

obtained, so that the invoking of the tannic acid retardation is not applicable.

We therefore maintain (i) that Ewart's tannic acid complications are not applicable to the experiments of Greenwood and Rothera; (ii) that Ewart is incorrect in assigning the tannic acid retardation to an action upon the starch; and (iii) that experimental results obtained under quite different conditions and with quite different proportions of reagents have been used in a wholly unjustifiable manner, as though applicable to Greenwood and Rothera's conditions, and reagent concentrations.

1.—Action of Tannic Acid on Filtered Starch Solutions.

1% tannic acid solution was added to 1% starch solution in the proportions of 1:1; 1:3; 1:7; and 1:15 respectively, the final concoctions of tannic acid being 0.5%; 0.25%; 0.125%, and 0.0625% respectively. They were mixed and kept at room temperature.

The first two gave a cloudiness immediately, which became dense on standing; but after eighteen hours there was no sign of a precipitate.

The third gave a very slight cloudiness on first mixing, but this became more marked on standing.

The fourth showed no appreciable change from a control to which an amount of water equal to the tannic acid solution had been added, but after standing eighteen hours there was a just perceptible difference.

In the course of one of the experiments, to be described later, 1% tannic acid and 1% filtered starch solutions were mixed, so that the final concentrations were .2% tannic acid, and .8% starch respectively. The starch solution had been made up five days previously, and had not been filtered in the meantime.

A cloudiness developed immediately on mixing, which was done at room temperature.

This was then placed in a water bath kept at 38°—40°C., with a control. At the temperature of the bath it became much clearer, being but little denser than the control (which contained .8% starch solution), and at the end of twenty-three hours there was a slight transparent precipitate at the bottom of both tubes, being slightly greater in that containing the tannic acid.

2.—*The Action of Tannic Acid on the iodine test for dextrins formed during diastatic action on starch.*

A final concentration of 1% tannic acid was found to have no effect on this test, as used in Greenwood and Rothera's, and the following experiments. This is because the conditions involve an excess of iodine. The interference of tannic acid with the starch and dextrin colours is due apparently to its forming a combination with the iodine, and naturally ceases when the iodine is in excess.

3.—*Action of Tannic Acid on the diastatic hydrolyses of starch.*

Filtered starch solution was used throughout the experiments, which were done at a temperature of 38°—40°C.

Experiment 1. (Tubes each contained 15 c.c. of mixture.)

Using a 2.5% solution of taka diastase, which proved rapid in action, the following mixtures were made up, and tested for comparative rates of action.

	Starch (1%).	Diastase (2.5%).	Tannic Acid (final concentration).
a (control)	10 c.c.	1 c.c.	0
b	10 c.c.	1 c.c.	.5%
c	10 c.c.	1 c.c.	.25%
d	10 c.c.	1 c.c.	.125%

c and *d* were finished in about 5½ minutes, and *a* about 2 minutes later. *b* still gave a strong red-brown at the end of 20 minutes.

Experiment 2. (Tubes each contained 10 c.c. of mixture.)

This was done, using taka diastase, with weaker concoctions of tannic acid than those used in Experiment 1.

	Starch (1%).	Diastase (2.5%).	Tannic Acid (final concentration).
a (control)	8 c.c.	1 c.c.	0
b	8 c.c.	1 c.c.	.1%
c	8 c.c.	1 c.c.	.05%
d	8 c.c.	1 c.c.	.025%

In 2 minutes, the control *a* still gave a red-violet, whilst the others were all red. *b* was finished in 5 minutes, *c* and *d* in about 8 minutes, and control *a* in 12 minutes.

Experiment 3. (Tubes each contained 10 c.c. of mixture.)
Using malt diastase.

	Starch (1%).	Diastase (2.5%).	Tannic Acid (final concentration).
a (control)	8 c.c.	1 c.c.	0
b	8 c.c.	1 c.c.	.1%
c	8 c.c.	1 c.c.	.05%
d	8 c.c.	1 c.c.	.025%

Although the acid and starch solutions were mixed before adding to the diastase, the concentrations of tannic acid were strong enough to cause a precipitate to form in the diastase solution. (This was *not* the case with taka diastase in Experiment 1.)

In 12 minutes the control *a* was well into the red, while the others were all blue. In 20 minutes *d* was beginning to show traces of violet, the others being still blue.

The effect on saliva was parallel, a precipitate being formed by .025% of tannic acid.

Experiment 4. (Tubes each contained 10 c.c. of mixture.)

This was done with weak taka diastase.

	Starch (1%).	Diastase (.25%).	Tannic Acid.
a (control)	8 c.c.	1 c.c.	0
b	8 c.c.	1 c.c.	.3%
c	8 c.c.	1 c.c.	.15%
d	8 c.c.	1 c.c.	.1%

These were left in a water bath overnight. The temperature started at 40°C., but fell to 36°C. during the night.

On testing, after 18½ hours, the control *a* had finished, *d* gave a very slight colour, *c* gave more colour (red), whilst *b* gave a very red brown.

In this experiment, concentrations of tannic acid, which gave an acceleration in the short experiments, here gave a very definite retardation.

The following experiments were done to determine whether this retardation was due to action on the ferment or on the starch.

Experiment 5. (Tubes each contained 10 c.c. of mixture.)

	Taka Diastase (2.5%).	Tannic Acid (final concentration).
a	8 c.c.	.2%
b	8 c.c.	.05%
c (control)	8 c.c.	0

These were kept in a water bath at 38°—40°C.

In 2 hours a fine, dispersed coagulum had appeared in about equal amounts in *a* and *b*.

This had slightly increased and settled out at the end of 23 hours, and by this time a slight precipitate had appeared in the control *c*. *a* and *b* were also darker in colour than *c*.

a, *b*, and *c* were shaken thoroughly, and 1 c.c of each was tested on 5 c.c. of starch solution (1%).

The control finished in 2½ minutes, *a* in 4 minutes, and *b* in 5½ minutes.

Although *a* had been in contact with a greater percentage of tannic acid, yet its action was quicker than that of *b*.

This may be explained by supposing that the formation of a coagulum was the sole inhibiting factor, and that the acceleration was caused by the presence of .04% of tannic acid in the final starch-diastase mixture, in the case of *a*, whereas only .01% was present when testing *b*. [No acid being present in control.]

Experiment 6. (Tubes each contained 10 c.c. of mixture.)

		Starch (1%).		Tannic Acid (final concentration).
a	-	8 c.c.	-	.2%
b	-	8 c.c.	-	.05%
c (control)	-	8 c.c.	-	0

In testing these, it was obviously necessary to compare them with the control in the presence of a corresponding amount of acid, hence the control was divided into two.

The following tubes were made up (each containing 5 c.c. of mixture).

		Starch.	Diastase.	Tannic Acid.	H_2O.
a	1	3 c.c. of *a*	1 c.c. 1% Taka diastase	0	1 c.c.
	2	3 c.c. of *c* (control)	,,	.6 c.c. of 1%	.4 c.c.
b	3	3 c.c. of *b*	,,	0	1 c.c.
	4	3 c.c. of *c* (control)	,,	.15 c.c. of 1%	.85 c.c.

1 and *2* then contained *.12%* of Tannic Acid
and *3* and *4* ,, ,, *.03%* ,, ,,

It was found that *1* and *2* went neck and neck (6 minutes), and at a faster rate than *3* and *4*, which also went neck and neck (10 minutes).

This experiment shows that the prolonged action of .2% tannic acid on .8% *filtered* starch solution does not materially affect its subsequent hydrolyses by taka diastase.

[PROC. ROY. SOC. VICTORIA 27 (N.S.), PART II., 1914.

ART. XVI.—*Notes on Australian and Tasmanian Scydmaenidae, with Descriptions of New Species.*

BY ARTHUR M. LEA.

[Read November 12th, 1914].

No family of beetles of equal extent in Australia and Tasmania has been so much neglected as the *Scydmaenidae*. Probably this has been largely on account of the unsatisfactory descriptions by the late Rev. R. L. King. So that, apart from the species named by him, very few have been recorded from Australia. The references are as follows:—

1. King, Trans. Ent. Soc. N.S. Wales, I., pp. 91-99.
2. Macleay, *l.c.* II., p. 155.
3. Sharp, Trans. Ent. Soc. London, 1874, p. 515.
4. Lea, Proc. Roy. Soc. Victoria, 1905, p. 377.
5. Lea, *l.c.* 1907, p. 153.
6. Lea, *l.c.*, 1910, pp. 181-189.
7. Lea, Proc. Linn. Soc. N.S. Wales, 1911, p. 456.

Some years ago I carefully examined all of King's and Macleay's types, now in the Australian Museum; and received from that institution most of their species. But for these circumstances I should probably have had to pass over all but a few of the species here described.

On preparing to work at a particular group of insects I usually write to many of my entomological correspondents, requesting the loan of specimens of the group; but with the *Scydmaenidae* the species in external appearance are so much alike, and the preparatory work is so extensive[1], and often unsatisfactory,[2] that I felt indisposed to do so in this instance. Mr. H. H. D. Griffith, however, allowed me to examine his collection of the family, and to retain such specimens as I desired. From Mr. H. W. Davey and others some ants' nest species were obtained, but these were noted elsewhere;[3] a few were obtained from correspondents in the ordinary course of exchange, and a few sent from the British Museum for

1. The majority of Australian collectors at present, unfortunately, seldom set out the legs and antennae of their beetles.

2. With single specimens it is often difficult to judge whether the absence of clothing from certain parts may be natural or due to abrasion.

3. In Proc. Roy. Soc. Victoria, 1910, pp. 181-189.

examination. I also examined all the Australian specimens of the family in the Macleay Museum, but as most of these were taken many years ago, and many are unique and difficult to clean, many were returned unnamed. Some of my own specimens are also left unnamed, although almost certainly new.

The majority of the specimens from New South Wales were taken during floods, and it is likely enough therefore that some of them are ants' nest species. From Tasmania a large percentage of the species were taken from mosses, lichens and tussocks;[1] and it is extremely probable that when mosses, etc., are well worked in other parts of Australia, undescribed species will be obtained in abundance. So far New South Wales and Tasmania are the only two States that have been (comparatively) well worked for species of the family.

Heterognathus armitagei, King.

Of this species King says, "Thorace fossula transversa basali"; on a co-type before me, however, there is at the base of the prothorax a close series of punctures, but they are separated, and not combined to form a transverse depression, although at a hasty glance they appear to be so.

Heterognathus gracilis, King.

Additional localities for this species are Tweed River, Forest Reefs and Glen Innes.

Heterognathus geniculatus, King.

Additional localities for this species are Glen Innes and Forest Reefs.

Heterognathus robustus, n.sp.

Of a rather dark reddish castaneous, suture slightly infuscated. Rather densely clothed with suberect, stramineous pubescence or short hairs.

Head moderately wide, with small, partially concealed punctures. Eyes of medium size, latero-frontal and fairly prominent. Antennae, for the genus, rather stout; club conspicuously three-jointed. *Prothorax* moderately convex, about as long as wide, sides rather strongly rounded, but becoming oblique to base; punctures very indistinct. *Elytra* rather short and wide, across base wider than widest part of prothorax, but across middle not

1. Some of these also are perhaps inquilines, as many ants are to be taken in such situations.

twice as wide; sides rather strongly and evenly rounded, with small, dense punctures, only partially concealed by clothing. *Legs* rather long and stout; hind coxae moderately separated. Length, 2 mm.

Hab.—Queensland; Mulgrave River (H. Hacker).

A robust, densely pubescent species, allied to *gracilis*, but larger and stouter, and elytra with dense and fairly distinct punctures. Considerably stouter than *carinatus*, ninth joint of antennae larger, and prothorax not carinated, etc.

The second-eighth joints of antennae are of almost even width, but gradually decrease in length, from slightly longer than wide to moderately transverse, the ninth joint is somewhat smaller than the tenth, and about twice as long and twice as wide as the eighth, the eleventh is subconical, slightly wider and distinctly longer than the tenth.

Two rather dirty specimens from Brisbane, in the Macleay Museum, probably belong to this species, but differ in having the abdomen slightly less convex; the clothing also is somewhat sparser, but this is probably due to abrasion.

Scydmaenus kingensis, Lea.

Tasmanian specimens of this species have the longitudinal impression on each side of the suture, near the base more distinct than on the type; so that conjoined they appear as a rather large depression, with the suture elevated in the middle of same. The antennae were originally described as with the "last four (joints) forming an elongate and loosely jointed club." Having had occasion to examine many species recently, this now appears incorrect to me, and the joints should be regarded as subcontinuous, and not forming a club; a distinction readily apparent on examining numerous species, whose antennae have the two, three, or four apical joints conspicuously clavate.

Scydmaenus gulosus, King.

This species may be taken in abundance during floods on several New South Wales rivers. There is also a specimen in the Macleay Museum from South Australia, and two from Victoria.

On most of the specimens the head and prothorax are of a deep shining black, but two specimens in the Macleay Museum from Sydney and Ash Island, and one in my own collection from Windsor, have the parts named not much darker than the elytra.

The front tibiae are dilated only in the male.

Scydmaenus parramattensis, King.

Additional localities for this species are Clarence River, Windsor and Tamworth.

Scydmaenus clarus, n.sp.

♂ Bright reddish castaneous; head prothorax and suture somewhat darker than elsewhere; palpi and tarsi flavous. Sides at base of head, and sides of prothorax, with moderately dense, flavous hairs; rest of upper surface entirely glabrous.

Head transverse; obtusely bilobed between antennae. Eyes small and prominent. Antennae rather long; club four-jointed. *Prothorax* about as long as wide, moderately convex; each side of base with a small deep fovea, the outer basal margins also foveate. *Elytra* at base scarcely wider than base of prothorax, sides dilated to near the middle; and then rounded to apex; basal impressions wide and conspicuous. *Metasternum* rather widely concave at middle of apex. *Legs* rather long; hind coxae rather distant; femora rather stout, the front pair stouter than the others. Length $1\frac{3}{4}$ mm.

♀ Differs in having the metasternum depressed only in middle of extreme apex, femora thinner and antennae somewhat thinner and shorter.

Hab.—Tasmania: Mount Wellington, Frankford, from fallen leaves and moss. (A. M. Lea.)

In appearance fairly close to *glabripennis*, but antennae rather stouter, and prothoracic impressions and clothing different.

At a glance the club appears to be subcontinuous with the other joints of the antennae, but the eighth joint is longer and suddenly (although not much) wider than the seventh, although as the following joints slightly increase in width, and the seventh is itself slightly wider than the sixth, the clubbing is not so pronounced as in many other species. The basal foveae of the prothorax from most directions appear to be completely isolated, but from others a vague connecting depression is visible; the outer ones are quite concealed from above.

On this and on all the following species of the genus the elytral punctures are so extremely sparse and faint that they are quite useless for purposes of identification; on the head and prothorax, if present at all, they are seen with difficulty, and only from certain directions.

Scydmaenus seminiger, n.sp.

Black; elytra dark castaneous, suture still darker, under surface dark reddish-brown or black, abdomen generally pale; legs and palpi flavous, antennae somewhat darker. Upper surface glabrous, except for numerous hairs at sides of prothorax, and a fascicle on each side of base of head.

Head moderately transverse, convex, rounded between antennae. Eyes small and prominent. Antennae moderately long and rather thin; club conspicuously four-jointed, but seventh joint distinctly longer and wider than sixth, although decidedly narrower and slightly shorter than eighth. *Prothorax* about as long as wide; base with two small deep foveae. *Elytra* rather wide and depressed; base slightly wider than base of prothorax, the basal impressions comparatively small; sides gently dilated to beyond the middle, and then regularly rounded to apex. *Legs* moderately long, hind coxae moderately separated; front tibiae somewhat inflated towards apex in male. Length, 1¼ mm.

Hab.—Victoria (Macleay Museum), Portland (H. W. Davey); N.S.W.: Forest Reefs; Tasmania: Jordan River, abundant in flood debris, New Norfolk, in tussocks, Hobart, in moss, Launceston (A. M. Lea).

The size and outlines are almost exactly as in *bifasciculatus*, but the colours and habits are very different. In general appearance, colours, etc., it is much like *glabripennis* in miniature; *gulosus* is frequently like it in colour, but is considerably narrower, with the elytra clothed. The black head and prothorax readily distinguish it from most of the species having the elytra glabrous.

The prothoracic foveae from some directions appear to be connected together by a strong transverse impression, but from other directions this impression appears rather faint; from some it causes the base to appear quadrifoveate.

Some specimens, from the Tweed River, differ in having some sparse straggling hairs about the basal third of the elytra, but I can find no other differences.

Scydmaenus fimbricollis, n.sp.

Bright castaneous, elytra (suture not at all) very little paler than head and prothorax, antennae somewhat paler; femora and tibiae almost, the tarsi and palpi quite, flavous. Upper surface glabrous, except for numerous stramineous hairs at sides of prothorax, and a small fascicle on each side of base of head.

Head moderately transverse, feebly bilobed between antennae. Eyes small and very prominent. Antennae rather long; club four-jointed. *Prothorax* about as long as wide; base with two small, deep and rather distant foveae. *Elytra* at extreme base no wider than base of prothorax; sides moderately dilated to just before the middle, thence narrowed to apex. *Legs* rather long; hind coxae separated almost the width of impression at apex of metasternum. Length, $1\frac{1}{3}$ mm.

Hab.—Tasmania: Jordan River, in flood debris, Hobart, Mount Wellington, in moss, Waratah. (A. M. Lea.)

Larger than *castaneoglaber*, elytra slightly longer in proportion, and prothorax conspicuously fringed. *Bifasciculatus*, which has a similar fringe, is shorter, with wider elytra and slightly shorter and thinner antennae. In general appearance rather like small specimens of *clarus*, but antennae thinner, although not longer, the joints of the club less closely articulated, and basal impressions of prothorax not quite the same.

The club is certainly four-jointed, but as its joints slightly increase in width, and as the seventh is distinctly wider and somewhat longer than the sixth, from some directions it almost appears to be five-jointed. From some directions a rather shallow impression connecting the prothoracic foveae is visible; but from others these appear to be completely isolated.

Scydmaenus flavoapicalis, n.sp.

Bright castaneous; elytra slightly paler, but becoming flavous at apex; legs and palpi flavous. Clothing as in preceding species.

Head moderately transverse; rounded between antennae. Eyes rather small and prominent. Antennae rather thin; club distinctly four-jointed. *Prothorax* slightly wider than long, with two deep basal foveae. *Elytra* moderately wide, at base slightly wider than base of prothorax, sides regularly rounded and widest just before middle. *Legs* long; hind coxae moderately separated. Length, $1\frac{1}{4}$ mm.

Hab.—N.S. Wales: Ropes Creek, Sydney (Macleay Museum), Clarence River, Forest Reefs, Tamworth, Windsor (A. M. Lea.)

Slightly larger than *castaneoglaber*, and prothoracic impressions connected across base; that species also has not a conspicuous lateral fringe of hairs. From the preceding species it differs in being slightly smaller, elytra rather less narrowed at base, and antennae shorter and thinner.

The flavous portion of the elytra varies from about one-fifth to about one-third; although very distinct, it is not sharply limited. The prothoracic foveae from some directions appear to be connected by a strong transverse impression; from other directions, however, the impression seems rather feeble, although it is always traceable.

Numerous specimens differ in having the head and prothorax almost or quite black, and such specimens sometimes have the apex of elytra scarcely flavous; but, as I can find no differences in clothing or structure, I presume they represent varieties only. They are coloured much as *seminiger*, except that the under surface is not dark; but their size is very slightly, although consistently, smaller than that of that species, and are also somewhat narrower.

Scydmaenus flavipes, n.sp.

Bright castaneous; elytra (suture excepted) somewhat paler; legs and palpi flavous. Clothing as in two preceding species.

Head (excluding neck) almost as long as wide, bilobed between antennae. Eyes small and moderately prominent. Antennae long and thin; club conspicuously four-jointed. *Prothorax* slightly longer than wide; depressed; base with two small deep foveae, with a conspicuous connecting impression. *Elytra* flat and comparatively narrow; widest about middle; basal impressions rather small. *Legs* long; hind coxae moderately separated. Length $1\frac{1}{4}$ mm.

Hab.—W. Australia: Swan River. (A. M. Lea.)

A small, depressed species, narrower than most of those having glabrous elytra. Except for the glabrous elytra, which, however, are rather wider, it is much like *atrophus*.

Scydmaenus subglabripennis, n.sp.

Castaneous, elytra (suture excepted) somewhat paler; legs and palpi flavous. Upper surface glabrous, except for numerous stramineous hairs at sides of prothorax, a few about base (including sides) of elytra, a few at sides of head, and a fascicle on each side of its base.

Head moderately transverse, rather strongly rounded between antennae. Eyes (for the genus) rather large. Antennae rather long and thin; club four-jointed. *Prothorax* about as long as wide, moderately convex; base with two small deep foveae. *Elytra* rather short and wide; at base distinctly wider than prothorax,

and thrice as wide about the middle. *Legs* long; hind coxae moderately separated. Length, 1⅓ mm.

Hab.—Queensland: Dalby. (Mrs. F. H. Hobler.)

The outlines are much as in *glabripennis*, but the colours and clothing are different, and club somewhat thinner, etc. The elytral clothing, although not dense, is fairly distinct, so I think it should not be placed with the species having glabrous elytra.

The seventh joint of the antennae is distinctly longer and wider than the sixth, but as it is very decidedly narrower and shorter than the eighth, it cannot be regarded as forming part of the club. The basal foveae of the prothorax are connected by an impression that from some directions appears to be deep and distinct, but from others is scarcely traceable.

Scydmaenus obscuricornis, n.sp.

Dark reddish castaneous; suture and eighth, ninth and tenth joints of antennae deeply infuscated; legs rather dark, tarsi and palpi pale, but scarcely flavous. Elytra with sparse, suberect, and moderately long, pale hairs; prothorax densely clothed at sides, and glabrous elsewhere; head very sparsely clothed, but with a loose fascicle on each side of base.

Head almost as long as wide; feebly bilobed between antennae. Eyes rather small and moderately prominent. Antennae rather long and thin; club conspicuously four-jointed. *Prothorax* about as long as wide; foveae and connecting impression as in preceding species. *Elytra* moderately long, at extreme base no wider than prothorax, sides regularly rounded and widest at about middle. *Legs* long; hind coxae moderately separated; femora subclavate. Length, 1⅓ mm.

Hab.—Tasmania: Hobart (A. M. Lea).

In size and shape like *insigniventris*, but club dark and otherwise different. The depression connecting the foveae together is very shallow (it is quite invisible from certain directions), and very different to that of *dentiventris*. The elytra are decidedly narrower than in the preceding species, and the club is much darker. The outlines are somewhat as in *Kingensis*, but the antennae and clothing are different. The outlines approach those of *glabripennis*, but that species has the elytra entirely glabrous, and head and prothorax much darker.

The seventh joint of the antennae is very little longer or wider than the sixth, and is only about half the width of the eighth.

A specimen, taken from under rotting leaves in the National Park (N. S. Wales), appears to belong to this species, but differs in having the elytral clothing confined to the basal third (perhaps from abrasion), and the elytra, under surface and legs somewhat paler.

Scydmaenus brevisetosus, n.sp.

Bright reddish-castaneous, elytra very little (the suture not at all) paler than head and prothorax; legs and palpi flavous. Elytra with very short and indistinct, but almost evenly distributed setae (scarcely pubescence); sides of prothorax with rather dense stramineous hairs, similar hairs forming a fascicle on each side of base of head.

Head about as long as wide, feebly bilobed between antennae. Eyes small and prominent. Antennae comparatively short and stout; club distinctly four-jointed. *Prothorax* slightly transverse; each side of base with two small foveae. *Elytra* at base slightly wider than prothorax; basal impressions smaller than usual; sides moderately dilated to near the middle, and then narrowed to apex; *Legs* rather long and stout; hind coxae moderately separated. Length, 1¼ mm.

Hab.—Tasmania: Mount Wellington, four specimens from moss. (A. M. Lea.)

The elytra at first appear to be glabrous, but on looking at them sideways some very fine suberect setae become noticeable. The first, second and eleventh joints of the antennae are longer than wide, all the others being transverse, the eighth, ninth and tenth are fully twice as wide as long; the seventh is just perceptibly longer and wider than the sixth. The prothoracic foveae are all connected together by a transverse impression that varies, according to the point of view, from faint to strongly defined; the lateral foveae are only partially visible from above, but from the sides each is seen to mark the base of a longitudinal impression.

Scydmaenus brevipilis, n.sp.

Bright reddish-castaneous elytra (suture excepted), very little paler; legs almost, the tarsi and palpi quite flavous. Elytra with short and rather sparse, but very distinct pale pubescence; prothorax with dense hairs at sides, and a few at base and sides of disc, but middle of disc glabrous; head with a small loose fascicle on each side of base, and sparsely clothed elsewhere.

Head slightly longer than wide, somewhat rounded and flattened between antennae. Eyes small and rather prominent. Antennae rather long and thin; club four-jointed. *Prothorax* distinctly longer than wide, rather convex; base with two rather large foveae. *Elytra* moderately long, extreme base no wider than prothorax, but almost twice as wide across middle. *Legs* long; hind coxae rather widely separated; femora subclavate. Length, $1\frac{3}{4}$ mm.

Hab.—Tasmania: Mount Wellington, Waratah, common in moss and fallen leaves. (A. M. Lea.)

About the size of *tenuicornis*, but rather narrower, antennae not abnormally long, and elytral clothing unusually short for the family. It is, however, more noticeable than in the preceding species, from which it also differs in being larger, appendages longer and thinner, and prothorax not quite the same. From *Phagonophana abundans*, the most abundant of all the moss frequenting species in Tasmania, it is readily distinguished by its smaller size, distinctly clubbed antennae, and shorter clothing.

The seventh joint of the antennae is slightly wider but no longer than the sixth; and decidedly narrower than the eighth; the latter is slightly narrower, but no shorter than the ninth, the two following combined are about as long as the eleventh. The prothoracic foveae are larger and closer together than usual; they are connected by a transverse impression that varies in apparent depth with the point of view; each also is more or less distinctly connected with a lateral fovea, or longitudinal impression, that is quite invisible from directly above.

Scydmaenus tenuicornis, n.sp.

♂ Castaneous, elytra scarcely or not at all paler than elsewhere; antennae and legs somewhat paler, tarsi and palpi flavous. *Elytra* with fairly numerous, and rather long, suberect pale hairs; prothorax rather densely clothed at sides, but greater portion of disc glabrous; head sparsely clothed and without fascicles.

Head moderately transverse; feebly impressed between antennae. Eyes of moderate size, but very prominent. Antennae unusually long and thin; club four-jointed. *Prothorax* slightly longer than wide, widest across apical third; with two large basal foveae, and a smaller longitudinal one on each outer margin, the four more or less distinctly connected by a transverse impression. *Elytra* rather long, at extreme base slightly narrower than widest part of prothorax, sides evenly rounded and widest almost in exact middle. *Metasternum* flattened along middle or very feebly concave. Abdo-

men with fourth segment concave in middle, the concave portion bounded on each side by a conspicuous ridge that terminates as an obtuse tooth. *Legs* long; hind coxae moderately separated; femora subclavate; front tibiae hooked at apex. Length, 1 4/5 mm.

♀ Differs in having the metasternum gently convex, abdomen with fourth segment simple, head bifasciculate, antennae and legs somewhat shorter, and front tibiae not hooked.

Hab.—Tasmania: Stanley, in tussocks on summit of "Nut," Hobart, in fallen leaves, Huon River. (A. M. Lea.)

The long and thin antennae, with peculiar abdomen and front tibiae of the male, render this species very distinct. Each joint of the antennae is at least twice as long as wide, except the three basal joints of the club, which, however, are distinctly longer than wide; the seventh is about as long as the eighth, but distinctly narrower.

Scydmaenus dentiventris, n.sp.

♂ Dark castaneous, elytra somewhat paler, antennae slightly paler than elytra, legs somewhat paler still, tarsi and palpi flavous. Elytra with moderately long and rather sparse stramineous hairs; on prothorax and head somewhat shorter and darker, on the former condensed at sides, and on the latter forming a loose fascicle on each side of base; abdomen more densely pubescent than usual.

Head moderately transverse, flattened between antennae. Eyes moderately large and rather prominent. Antennae long and thin; club distinctly four-jointed. *Prothorax* feebly transverse; base foveate and impressed. *Elytra* moderately wide and rather depressed, base wider than prothorax, sides evenly rounded, and widest across middle. *Metasternum* rather convex. Abdomen with fourth segment tridentate. *Legs* rather long; hind coxae rather distant; front trochanters triangularly dentate. Length, 1½ mm.

♀ Differs in having fourth segment of abdomen simple, front trochanters unarmed, and eleventh joint of antennae shorter.

Hab.—Tasmania: Hobart, from sods of grass, Huon River, in tussocks, Swansea, Stanley; N. S. Wales: Glen Innes, Tamworth, Wollongong, Windsor (A. M. Lea), Nepean River (A. J. Coates).

The colour is much as in the typical form of *gulosus*, and in general appearance it is close to *latebricola*, but readily distinguished from these by the basal impressions of prothorax, and the abdomen. The teeth on the abdomen of the male are of even length, and very much smaller than in *insigniventris*, with the outer ones more distant from the margins. Seen directly from above, the

fourth segment appears bifoveate, with the teeth marking the boundaries of the foveae; looking at them, from the direction of the head they appear as three rather acute teeth; from some directions they appear as short acutely terminated ridges, on the same plane as the base of the segment.

The seventh joint of the antennae is slightly larger than the sixth, and conspicuously smaller than the eighth, the eighth, ninth and tenth are each slightly dilated to the apex, the eleventh is slightly longer than the ninth and tenth combined. The basal prothoracic foveae and the connecting impression are somewhat variable, the foveae sometimes are rather large, shallow, and two in number, with the connecting impression rather feeble. On other specimens the impression appears more distinct, and with two or four foveate expansions. It is connected on each side with a longitudinal impression that is quite invisible from above.

One of the Hobart specimens has the elytra darker than the others, and with a faint infuscation along suture. The Swansea ones are also so coloured. Two females from Cunnamulla (Qld.), taken by Mr. Hardcastle, appear to belong to the species, but are of a rather light castaneous, with the elytra still paler. A specimen from South Australia, in the Macleay Museum, appears to belong to the species, but is abraded; and, as it is somewhat dirty, I have not been able to examine it satisfactorily.

Scydmaenus tridentatus, n.sp.

♂ Bright castaneous, head and prothorax somewhat darker than elsewhere, tarsi and palpi flavous. Clothing much as in preceding species.

Head moderately transverse, very feebly bilobed between antennae, with two very indistinct impressions close to each eye. Eyes small and prominent. Antennae slightly shorter, but otherwise much as in preceding species. *Prothorax* lightly transverse; base foveate and transversely impressed. *Elytra* moderately wide, and gently convex, base distinctly wider than prothorax, sides regularly rounded and widest just before middle. *Abdomen* with fourth segment armed. *Legs* rather long; front coxae rather distant; femora stout, especially the front pair. Length, $1\frac{3}{4}$ mm.

♀ Differs in having the antennae shorter, front femora not quite so stout, and abdomen unarmed.

Hab.—W. Australia: Swan and Vasse Rivers. (A. M. Lea.)

The teeth on the fourth segment of the abdomen of the male are intermediate between those of *insigniventris* and *dentiventris*, differing from the former in being shorter, not quite as close to the margins, on the same plane as the base of the segment, and the median tooth quite distinctly a tooth, and not a slight thickening of a membranous flap, although remnants of such a flap are present. From the latter species it differs in the outer teeth being decidedly longer than the middle one, more distant from each other, and conspicuously projecting as teeth over the fifth segment. To see them most clearly they should be examined from the direction of the head, as, in this species and in *dentiventris*, they are somewhat obscured by clothing.

The base of the prothorax is transversely impressed, with the impression foveate, but the depressed parts are somewhat obscured by clothing.

A female, possibly belonging to this species, differs in being somewhat wider, elytra more densely clothed, head with rather dense clothing across base, and femora and tibiae almost flavous.

Scydmaenus fimbriatus, n. sp.

Of a rather dingy castaneous, suture somewhat darker than rest of elytra; tarsi and palpi flavous. Elytra with rather short and depressed stramineous hairs, prothorax rather densely clothed at sides, and sparsely elsewhere; not at all on middle of disc; head sparsely clothed, except at sides and in middle of base, where the clothing is dense.

Head feebly transverse; moderately bilobed between antennae. Eyes small and moderately prominent. Antennae moderately long; club conspicuously four-jointed. *Prothorax* lightly transverse; base foveate. *Elytra* not very wide, base distinctly wider than prothorax, sides regularly rounded and widest across middle. *Legs* rather long; hind coxae moderately separated; femora subclavate. Length, 1¾mm.

Hab.—N. S. Wales: Ourimbah, from rotting leaves. (A. M. Lea).

The general shape and appearance is much like that of *Heterognathus robustus*, but the club is distinctly four-jointed. At a glance it appears close to the preceding species, but the bases of the prothorax and elytra are different; the elytra and their clothing are not as in *brevipilis*.

The cephalic fascicles are not separated the entire width of the base, but appear extended round and almost drawn together, caus-

ing the head to be more densely clothed at the base than is usual, so that it is really without true fascicles. The seventh joint of the antennae is very little larger than the sixth, and not half the width of the eighth, the latter is practically the same size as the ninth or tenth. These combined are the length of the eleventh. At the base of the prothorax there are two small round foveae, somewhat closer together than is usual; there is also another fovea on each margin, but partly visible from above; all four are connected by an impression that varies in apparent depth according to the point of view; the lateral foveae are each connected by an oblique impression. The elytra are suppled with fairly numerous punctures, of small size certainly, but readily visible under a Coddington lens, in which respect they differ from the other species here described.

Scydmaenus amplipennis, n.sp.

♂ Bright castaneous, head and prothorax somewhat darker than elsewhere, tarsi and palpi flavous. Elytra with rather sparse and not very long stramineous hairs; prothorax not very densely clothed at sides, and glabrous elsewhere; head very sparsely clothed and without fascicles.

Head slightly longer than wide, feebly bilobed between antennae. Eyes small and prominent. Antennae moderately long; club inconspicuously four-jointed. *Prothorax* distinctly longer than wide; base with two somewhat irregular foveae. *Elytra* at base wider than prothorax, and rather more than twice as wide about the middle, subobliquely dilated to near the middle, and then rounded to apex. *Metasternum* lightly convex. Abdomen with fourth segment bidentate. *Legs* long; hind coxae rather widely separated; front trochanters triangularly dentate. Length, $1\frac{3}{4}$ mm.

♀ Differs in having abdomen simple, and legs somewhat shorter, with the front trochanters unarmed.

Hab.—N. S. Wales: Sydney. (Macleay Museum), Forest Reefs. (A. M. Lea.)

Readily distinguished from most species of the genus by the comparatively small prothorax, large elytra and bidentate abdomen. The second to seventh joints of antennae are practically of even width, and the seventh is not much, certainly not conspicuously so, narrower than the eighth, so that the antennae might almost fairly be regarded as having the joints of subcontinuous width, and with the club rather feebly defined; still it is defined, and this, with the separation of the hind coxae, evidently distinguishes the species

from *Phagonophana*, to several species of which it is rather close in general appearance.

From certain directions the head appears to have a small but very distinct fovea close to each eye; from other directions, however, it appears no more than a very shallow and indistinct impression. The basal foveae of the prothorax are somewhat transverse, closer together and less rounded than usual, and with a feeble connecting impression; the impression continued to connect with a longitudinal impression on each side. The teeth on the fourth abdominal segment of the male are moderately large and close together, and project backwards on the same plane as the rest of the segment; from certain directions they appear to be connected by a basal membrane, but there is no trace of a smaller median tooth.

Scydmaenus tenuicollis, n.sp. or var.

Head and prothorax rather dark reddish-castaneous; elytra about base and basal half of suture not much paler, but decidedly paler elsewhere, and becoming almost flavous posteriorly; legs and palpi flavous. Clothing much as in preceding species.

Head and antennae as in preceding species. *Prothorax* and *elytra* narrower, but otherwise much the same. *Legs* long; hind coxae rather widely separated. Length, $1\frac{3}{4}$ mm.

Hab.—Tasmania: Huon River. (A. M. Lea.)

In general appearance very close to the preceding species, of which it is perhaps a variety, but the prothorax and elytra are slightly narrower, and the latter are somewhat paler. I am acquainted with but a single specimen, evidently a female.

Scydmaenus mastersi, n.sp.

♂ Of a rather dingy castaneous, legs paler, tarsi and palpi flavous. Elytra with sparse and short depressed hairs, prothorax rather densely clothed at the sides in front but sparsely elsewhere, head sparsely clothed and without fascicles.

Head moderately transverse; feebly bilobed between antennae. Eyes rather small and prominent. Antennae moderately long; club distinctly four-jointed. *Prothorax* about as long as wide; base with two strong foveae. *Elytra* rather wide and convex; at base wider than prothorax, and across middle fully twice as wide, sides rather strongly and evenly rounded. *Metasternum* moderately convex. *Legs* moderately long; hind coxae distinctly, but not very widely separated; front tibiae somewhat inflated towards apex. Length, $1\frac{1}{4}$ mm.

♀ Differs in having the metasternum rather more convex, and front tibiae thinner, with the legs in general somewhat shorter.

Hab.—N. S. Wales: Tweed River (Macleay Museum and A. M. Lea); Clarence River, Tamworth (Lea).

Allied to *gulosus*, and with the front tibiae also inflated in the male; but head and prothorax paler, size slightly smaller and clothing sparser, etc. Smaller than the pale form of *dentiventris*, and prothorax different at base. Wider than *rivularis* and prothoracic impressions and colours different. Narrower than *depressus* and *griffithi*, elytra less depressed, and different at base, and prothoracic foveae different.

The colour of the upper surface is usually of a uniform dingy castaneous, but on some specimens the elytra (suture excepted) are slightly paler than the prothorax and head. The seventh joint of the antennae is somewhat larger than the sixth, but is slightly shorter and conspicuously narrower than the eighth. The prothoracic foveae are connected by an impression that is not very distinct, although traceable, from some directions, but very distinct, and apparently deep, from others.

Scydmaenus usitatus, n.sp.

Of a rather bright reddish-castaneous, elytra sometimes slightly paler than head and prothorax; legs and palpi flavous. Elytra with fairly numerous but rather short, suberect pale hairs; prothorax rather densely clothed at sides; head with a distinct but rather loose fascicle on each side of base.

Head moderately transverse; feebly bilobed between antennae. Eyes small and prominent. Antennae moderately long; club conspicuously four-jointed. *Prothorax* slightly longer than wide, base bifoveate. *Elytra* moderately long, at extreme base the width of prothorax, but about once and one-half as wide across middle, sides moderately and regularly rounded. *Legs* moderately long; hind coxae moderately separated; front tibiae with apical half somewhat inflated. Length, $1\frac{1}{4}$ mm.

♀ Differs in having the metasternum more strongly convex; legs somewhat shorter, and front tibiae less inflated towards apex.

Hab.—Tasmania: Stanley, in tussocks at summit of "Nut," Hobart, in moss, Waratah, (A. M. Lea.)

From the preceding species distinguished by having elytra decidedly narrower, with the hind coxae more noticeably separated; the clothing and prothoracic sculpture are also not the same. It

is certainly close to *gulosus*, but the head and prothorax are not shining black as in that species, and the inflation of the front tibiae is somewhat different. It is smaller and hairier than *colobopsis*, more densely clothed than *depressus* and *griffithi*, less depressed; elytra and prothorax not quite the same as base, and antennae somewhat shorter.

The eighth joint of the antennae is fully twice the width of the seventh. The basal foveae of the prothorax are larger and closer together than usual; connecting them is a short impression that appears quite absent from some directions, but from other causes than to appear confluent; the impression is continued to each side, where it joins in with a lateral impression, which, however, is partially concealed by clothing.

One specimen has the metasternum and abdomen almost black.

Scydmaenus pilosicollis, n.sp.

Dark castaneous, elytra slightly paler than prothorax, legs pale castaneous, tarsi and palpi flavous. Elytra with moderately dense, suberect, short, pale hairs; prothorax densely clothed at sides, and sparsely elsewhere; head rather sparsely clothed, but with a loose fascicle on each side of base.

Head moderately transverse; very indistinctly bilobed between antennae. Eyes small and prominent. Antennae moderately long; club four-jointed. *Prothorax* slightly longer than wide; base with two large and almost confluent foveae in middle, and one on each side. *Elytra* with outlines as in preceding species. *Legs* moderately long; hind coxae distinctly, but not very widely separated. Length, 1¼ mm.

Hab.—Tasmania: Hobart, from moss, Long Bay, (A. M. Lea.)

Slightly larger, hairier, and with slightly stouter and less conspicuous club than in the preceding species, and prothoracic impressions deeper. Larger, hairier, and wider than *rivularis*. Slightly smaller than *colobopsis*, narrower, more convex and more densely clothed, and basal parts of prothorax and elytra not quite the same.

The disc of the pronotum, although not densely clothed, is not glabrous as in so many species of the genus. The seventh joint of the antennae is slightly larger than the sixth, and almost two-thirds of the width of, and somewhat shorter than, the eighth; the latter is somewhat narrower than the ninth, so that the club is not very conspicuously four-jointed, although quite decidedly so. The pro-

thoracic foveae are unusually large, and the lateral ones are partially vsiible from above; they are all so close together that there is not room for a conspicuous connecting impression, but from some directions the base appears to be conspicuously traversed by a rather deep impression.

Scydmaenus latebricola, n.sp.

Black, under surface piceous; prothorax diluted with red at base; elytra dark castaneous, antennae paler; palpi and legs flavous, knees slightly infuscated. Elytra with rather long, suberect, pale hairs; prothorax densely clothed at sides and glabrous elsewhere; head with a loose fascicle on each side of base, very sparsely clothed elsewhere.

Head slightly longer than wide; very indistinctly bilobed between antennae. Eyes small and prominent. Antennae of moderate length; club conspicuously four-jointed. *Prothorax* distinctly longer than wide; with two round, moderately deep, but not very large foveae, isolated from each other, but each connected with one on the side. *Elytra* moderately long; base distinctly wider than prothorax, and almost twice as wide across middle, sides moderately and evenly rounded. *Legs* moderately long; hind coxae distinctly but not very widely separated. Length, 1½ mm.

Hab.—Tasmania: New Norfolk, in tussocks, (A. M. Lea.)

Very close to *gulosus*, but a trifle larger, club somewhat stouter and shorter, head more densely clothed, prothorax more densely clothed at sides, and elytra darker, with longer clothing. From *clientulus* it differs in being larger and darker, club stouter, and clothing longer and darker. It is rather like a large specimen of the preceding species, but the prothoracic foveae are different, and the hind coxae are a trifle closer together.

The eighth joint of the club is the length of, but slightly narrower than, the ninth, but is fully twice the width of the seventh, the latter is very little larger than the sixth. The lateral foveae of the prothorax are partially visible from above; the impression connecting each with one of the medio-basal foveae is very conspicuous from some directions, but apparently absent from others.

One specimen has the entire upper surface of a dark castaneous.

Scydmaenus walkeri, n.sp.

Bright reddish-castaneous, legs somewhat paler, tarsi and palpi flavous. Elytra with rather short and subdepressed pale hairs;

prothorax sparsely clothed at the sides and glabrous elsewhere; head glabrous, even at the sides.

Head moderately transverse; rounded between antennae. Eyes small and moderately prominent. Antennae moderately long and thin; club distinctly four-jointed. *Prothorax* rather convex, about as long as wide; base bifoveate. *Elytra* rather wide, at base distinctly wider than prothorax, and more than twice as wide across middle; sides rather strongly and evenly rounded. *Legs* long; hind coxae moderately separated. Length, $1\frac{1}{3}$ mm.

Hab.—N. W. Australia: Upper Ord River (R. Helms), Adelaide River (British Museum, from J. J. Walker).

Rather close to *mastersi*, but antennae longer and thinner, and prothorax not quite the same.

At a glance the antennae appear to have the joints of subcontinuous width, but the eighth joint, although distinctly narrower than the ninth, is almost twice the width of the seventh; the latter is distinctly, but not much, larger than the sixth. The prothoracic foveae are rather small; from some directions a fairly distinct connecting impression is visible, but from others it appears to be entirely absent.

Scydmaenus calviceps, n.sp.

Colours and clothing much as in preceding species, except that on the elytra the hairs are slightly shorter.

Head moderately transverse, flattened and almost straight between antennae. Eyes of moderate size and moderately prominent. Antennae rather short; club conspicuously four-jointed. *Prothorax* about as long as wide; base with two rather large round foveae, close together, but without a connecting impression. *Elytra* with outlines much as in preceding species. *Metasternum* rather convex. *Legs* moderately long; hind coxae closer together than usual, although distinctly separated; front tibiae somewhat inflated in male. Length, $1\frac{1}{4}$ mm.

Hab.—N. S. Wales: Tweed River. (A. M. Lea.)

From the many similarly coloured species readily distinguished by the isolation of the prothoracic foveae, and the rather short antennae, with stouter club than usual; the clothing also is decidedly shorter than usual. From the pale form of *gulosus*, which has the foveae similarly isolated, the much shorter antennae are sufficently distinctive. In appearance it is close to *mastersi*, but is slightly smaller, and antennae shorter, with club decidedly stouter; the prothoracic foveae are also somewhat different. In general ap-

pearance it is very close to the preceding species, but antennae are decidedly shorter, with the ninth and tenth joints distinctly twice as wide as long, instead of not much wider than long. The eighth joint is as long as the ninth, but slightly narrower, and is fully twice the width of the seventh, the latter is scarcely perceptibly larger than the sixth.

Scydmaenus depressus, n.sp.

Bright pale castaneous, suture slightly darker than the rest of the elytra; legs and palpi flavous. Elytra with sparse, subdepressed, pale hairs, prothorax moderately clothed at sides, and glabrous elsewhere; head with a feeble fascicle on each side of base; very sparsely clothed elsewhere.

Head moderately transverse, very feebly bilobed between antennae. Eyes small and prominent. Antennae rather long; club conspicuously four-jointed. *Prothorax* almost as long as wide; base bifoveate. *Elytra* wide and somewhat depressed; base distinctly wider than prothorax, and more than twice as wide across middle; sides strongly and evenly rounded. *Metasternum* more convex than usual. *Legs* long; hind coxae moderately separated; femora subclavate. Length, 1 mm.

Hab.—South Australia (Macleay Museum), Adelaide, (H. H. D. Griffith).

A small depressed species with comparatively wide elytra, long antennae and legs, and short clothing. It is fairly close to *mastersi*, but is more depressed, and the antennae are stouter, with the club shorter. It is rather wider than *calviceps*, and the prothoracic impressions are different.

The eighth joint of the antennae is feebly tranverse, about twice the width of the seventh, and slightly narrower than the ninth, the latter in turn being slightly narrower than the tenth; the eleventh is briefly ovate, and very decidedly shorter than the two preceding combined; the seventh is very little larger than the sixth, the basal foveae of the prothorax are rather more widely separated than usual; connecting them is an impression that is only moderately distinct from some directions, but which from others causes the base to appear transversely sulcate.

Scydmaenus griffithi, n.sp.

Dark castaneous, elytra (suture excepted) generally somewhat paler; under surface piceous or black; legs and palpi castaneous.

Elytra with not very numerous and rather short, subdepressed, pale hairs; prothorax moderately clothed at sides, great portion of disc glabrous; head sparsely clothed, without basal fascicles.

Head about as long as wide; feebly bilobed between antennae. Eyes of moderate size and rather prominent. Antennae long and rather thin; club conspicuously four-jointed. *Prothorax* slightly longer than wide; base with two foveae of moderate size, and connected by a rather strong impression. *Elytra* moderately long, base slightly wider than prothorax, and almost twice as wide across middle; sides moderately and evenly rounded. *Legs* moderately long; hind coxae distinctly but not very widely separated; front tibiae dilated to apex in male. Length, 1 1/6 mm.

Hab.—South Australia: Adelaide, (H. H. D. Griffith.)

Darker than the preceding species, with longer antennae and with narrower and longer elytra; the suture is subdepressed towards the base, as it is also in that species, although this character is not of much use in distinguishing species. It is a trifle larger than *rivularis*, joints of club more rounded, prothoracic foveae less sharply defined, more distant, and with a feeble connecting depression; and the head and prothorax not shining black as in that species. The antennae are decidedly longer and thinner than in *usitatus*. The head has a shallow impression close to each eye, but from certain directions each of the impressions appears like a small fovea, much as in *amplipennis*, a species which otherwise it has little in common with.

One female has the body entirely pale castaneous, with the appendages flavous, but it is probably immature.

Scydmaenus fuscipalpis, n.sp.

Dark castaneous, suture still darker, under surface black, femora deeply infuscated, tibiae and palpi paler, tarsi flavous. Clothing much as in the preceding species, except that the entire disc of the pronotum is glabrous, and that the head has a loose fascicle on each side of the base.

Head moderately transverse; very indistinctly bilobed between antennae. Eyes small and prominent. Antennae long and moderately thin; club four-jointed. Prothorax distinctly longer than wide, base bifoveate. *Elytra* somewhat depressed; outlines as in preceding species. Legs moderately long; hind coxae moderately separated. Length, $1\frac{1}{4}$ mm.

Hab.—S. Australia: Adelaide (H. H. D. Griffith).

Like an enlarged form of the preceding species, but darker, even as to the legs, it is one of the very few species whose palpi are not entirely flavous.

The club is distinctly four-jointed, the eighth joint of the antennae, however, is distinctly narrower and more rounded than the ninth, and scarcely twice the width of the seventh, the latter is slightly larger than the sixth; the eleventh is almost as long as the ninth and tenth combined, The basal foveae of the prothorax, are fairly large, close together, and with a connecting impression, that is always traceable, but varies in apparent depth with the point of view.

Scydmaenus evanidus, n.sp.

Of a rather bright castaneous, antennae somewhat paler; legs and palpi flavous. Elytra with short, sparse pale, depressed hairs (almost pubescence); prothorax sparsely clothed at sides, and glabrous elsewhere; head almost glabrous, without basal fascicles.

Head moderately transverse; gently rounded between antennae. Eyes rather small and moderately prominent. Antennae long and rather thin; club conspicuously four-jointed. *Prothorax* somewhat depressed, slightly longer than wide; base bifoveate. *Elytra* depressed, base distinctly wider than prothorax and about twice as wide across middle; sides moderately and evenly rounded. *Metasternum* rather lightly convex. *Legs* moderately long; hind coxae moderately separated. Length, 4/5th mm.

Hab.—N. S. Wales: Tamworth (A. M. Lea).

A minute, depressed species, with thin antennae. In general appearance it is close to *Scydmaenilla pusilla*, but antennae with the club four-jointed, and hind coxae distinctly separated.

The eighth joint of the antennae is scarcely, if at all, narrower than the ninth, and twice the width of the seventh; the latter is slightly but noticeably larger than the sixth. The prothoracic foveae are round and rather deep, but not very large, from some directions they appear to be isolated, but from others a faint connecting impression is traceable.

Scydmaenus rivularis, n.sp.

Black; elytra and extreme base of prothorax deep reddish-castaneous; antennae and abdomen somewhat paler; legs and palpi flavous. Elytra with fairly numerous and rather short, subdepressed, pale hairs; prothorax densely clothed at sides and glabrous elsewhere; head sparsely clothed; each side of base with a feeble fascicle.

Head lightly transverse; feebly bilobed between antennae. Eyes small and prominent. Antennae moderatly long and not very thin; club conspicuously four-jointed. *Prothorax* slightly longer than wide; base with two rather small, round, deep foveae, close together, but without a connecting impression; each side with a small fovea, also isolated from the median ones. *Elytra* rather long, base not much wider than prothorax, and not twice as wide across middle, sides moderately and evenly rounded. *Legs* moderately long; hind coxae distinctly but not widely separated; tibiae somewhat stouter in male than in female. Length, $1\frac{1}{4}$ mm.

Hab.—Victoria; N. S. Wales: Sydney (Macleay Museum), Nepean River (A. J. Coates), Tweed, Clarence, Hawkesbury and Peel Rivers, abundant in flood debris (A. M. Lea).

The prothoracic foveae are more sharply defined and closer together than usual. The colours are much as in *gulosus*, but that species is somewhat larger and wider, prothoracic foveae separated almost twice the distance, base of elytra not quite the same, and joints of club more globular. *Paramattensis* is also larger and wider, antennae longer, and club and base of elytra different. The eighth joint of the antennae is very decidedly narrower than the ninth, although almost twice the width of the seventh.

On an occasional specimen the metasternum is not much darker than the elytra; and one specimen has the entire body pale castaneous, with the appendages still paler, but it is probably immature.

Scydmaenus foveidistans, n.sp.

♂ Dark castaneous; metasternum almost or quite black; legs and palpi flavous, antennae somewhat darker. Elytra with moderately numerous, short, subdepressed hairs, prothorax not very densely clothed at sides and sparsely elsewhere, only middle of disc glabrous; head sparsely clothed, basal fascicles very feeble and indistinct.

Head about as long as wide; gently rounded between antennae Eyes small and prominent. Antennae moderately long; club conspicuously four-jointed. *Prothorax* about as long as wide; base bifoveate. *Elytra* moderately long, extreme base no wider than prothorax, and across middle less than twice as wide; sides rather lightly and evenly rounded. *Metasternum* rather lightly convex. *Legs* moderately long; hind coxae distinctly but not widely separated; front coxae inflated. Length, 1 mm.

♀ Differs in having the metasternum more convex, the appendages somewhat shorter, with the front tibiae thinner.

Hab.—N. S. Wales; Nepean River (A. J. Coates), Tamworth, Windsor (A. M. Lea).

Smaller, darker, wider and more depressed than the preceding species, and prothoracic impressions different; the basal foveae are rather small and widely separated, but with a connecting impression that appears very distinct from some directions, although rather feeble from others. It is considerably smaller than *mastersi*, *usitatus* and *gulosus*.

The eighth joint of the antennae is about twice the width of the seventh, and almost the width of the ninth. The front coxae of the male are distinctly inflated from near the base to near the apex, but then decrease to the apex itself, as a result their outer edge has a somewhat rounded outline.

One specimen has the elytra darker than the prothorax, a reversal of the usual colours in species of the genus.

Scydmaenus appropinquans, n.sp.

Very dark brownish castaneous, elytra (suture excepted) generally slightly paler; metasternum black; abdomen usually black, but tip obscurely diluted with red; antennae and legs of a rather dingy pale castaneous, tarsi and palpi paler, but scarcely flavous. Elytra with short, sparse, depressed hairs or pubescence; prothorax rather sparsely clothed at sides, and glabrous elsewhere; head almost glabrous, without basal fascicles.

Head about as long as wide, very indistinctly bilobed between antennae. Eyes small and not very prominent. Antennae slightly longer, but otherwise much as in preceding species. *Prothorax* about as long as wide; base with two sharply defined foveae of moderate size, closer together than usual, and with a very feeble connecting impression. *Elytra* subdepressed and rather wide; base distinctly wider than prothorax, and about twice as wide across middle; sides rather strongly and evenly rounded. *Legs* moderately long; hind coxae lightly but distinctly separated, front tibiae somewhat stouter in male than in female. Length, 1 mm.

Hab.—W. Australia: Vasse River, in flood debris (A. M. Lea).

Close to *rivularis*, but somewhat smaller, prothoracic foveae somewhat different, antennae shorter, and joints of club smaller. Also close to the preceding species, but prothoracic foveae larger

and much closer together, with the connecting impression scarcely traceable from certain directions, and not at all from others.

The elytra, although always dark, are usually somewhat paler than the head and prothorax.

A specimen in the Macleay Museum, from Victoria, is very close, to if not identical with this species; its elytra are rather darker, but I can find no other differences.

Scydmaenus atrophus, n.sp.

Bright castaneous, antennae and legs somewhat paler, tarsi and palpi flavous. Elytra with rather short, sparse, pale, depressed hairs or pubescence; prothorax sparsely clothed at sides, greater portion of disc glabrous; head very sparsely clothed, a few hairs on each side at base, but scarcely forming fascicles.

Head lightly transverse; feebly bilobed between antennae. Eyes small and prominent. Antennae rather long; club conspicuously four-jointed. *Prothorax* somewhat depressed, and slightly longer than wide; base bifoveate. *Elytra* long, at extreme base no wider than prothorax, and scarcely once and one-half across middle; sides gently and evenly rounded. *Metasternum* rather longer than usual, and moderately convex. *Legs* moderately long; hind coxae distinctly but not very widely separated; front tibiae rather stouter in male than in female. Length, 1 mm.

Hab.—W. Australia: Swan and Vasse Rivers (A. M. Lea).

A small, narrow, species, in build close to the preceding species, but slightly narrower, much paler and prothoracic impressions different; the basal foveae are distinctly transverse, rather large, distinctly (at least from certain directions) connected with one on each side, but indistinctly connected with each other. It is smaller and distinctly narrower than *duplicatus* and *griffithi*, and the prothoracic impressions are different. It is much the size and colour of *Scydmaenilla pusilla*, but the club and hind coxae are different.

The eighth joint of the antennae is twice the width of the seventh, and fully as wide as the ninth.

Phagonophana suturalis, n.sp.

Dark reddish-castaneous; elytra (suture excepted) and appendages paler. Rather densely clothed with moderately long, suberect, stramineous hairs.

Head moderately long. Eyes small, latero-frontal and promi-nent. Antennae fairly stout, passing middle coxae, joints of sub-continuous width. *Prothorax* slightly longer than wide; base with irregular foveae, partially obscured by clothing. *Elytra* at ex-treme base the width of prothorax, but considerably wider across middle, sides strongly and evenly rounded; each side of base with two rather large impressions, of which the inner one is the smaller; narrowly striated on basal fourth close to suture; with small, irre-gularly distributed and usually indistinct punctures. *Legs* stout and rather long; hind coxae almost touching; femora not pedunculate. Length, 2 mm.

Hab.—Tasmania: Mount Wellington, in moss (A. M. Lea).

Considerably smaller and somewhat narrower than *latipennis*, with denser and paler clothing, and femora approaching the normal. It is stouter than the following species, antennae stouter, clothing denser and longer, and elytra with sides regularly rounded.

The clothing is denser on head and sides of prothorax than else-where, on the head almost entirely concealing its sculpture. The eyes are on a lower plane than usual, so that, although distinctly projecting from their surroundings, they are not very conspicuous from above. The second joint of the antennae is shorter than the first, but longer than the third, the latter is about as long as wide, but with the front edge narrowed to its junction with the fourth, the fifth to tenth have their apices similarly narrowed,[1] the tenth is about twice as wide as the third, but the intervening joints so regularly decrease in size, that the antennae cannot be regarded as having a club; the eleventh joint is subconical, and slightly longer than the two preceding combined. Close to the base and imme-diately on each side of the suture there is impressed a very fine stria, immediately outside of which there is a still finer stria, which is continued for a short distance beyond the first; but they are rather indistinct from some directions. Seen from the direc-tion of the head the hind coxae appear rather widely separated, but when examined from along the abdomen they are seen to be almost touching.

Phagonophana abundans, n.sp.

♂ Dark castaneous, elytra, abdomen and appendages somewhat paler, palpi and tarsi flavous. Moderately clothed with not very long, suberect, stramineous hairs.

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1. Similarly shaped joints in the *Pselaphidae* are described by M. Raffray as trapezoidal.

Head moderately long, with a small and rather shallow impression close to each eye. Eyes small, latero-frontal and prominent. Antennae rather long and thin, second to sixth joints of even width, the others slightly and regularly increasing in width, and not distinctly clubbed, eleventh subconical, slightly longer than two preceding joints combined. *Prothorax* strongly convex, and very decidedly longer than wide; base with four impressions, the two outer marginal and longitudinal, but partially visible from above, the two inner round and fairly large foveae; the space between them appearing almost as a carina. *Elytra* at extreme base the width of prothorax, sides strongly obliquely dilated to the basal two-fifths, where the width is more than twice that of the prothorax, then rounded, and then somewhat oblique to apex; each side of base depressed, the depression causing each side to appear like a small projecting tooth; with sparse, rather small, and more or less concealed punctures. *Metasternum* somewhat flattened across middle of apex. Abdomen with fourth segment having a strong raised double ridge on each side of middle, the middle of its apex excavated, and with a smaller ridge or tooth. *Legs* long; hind coxae moderately separated; femora subclavate. Length, 1 4/5-2 mm.

♀ Differs in having metasternum more convex, abdomen simple, and appendages somewhat shorter.

Hab.—Tasmania: New Norfolk, Hobart, Mount Wellington, numerous specimens from moss and several from fallen leaves.

Seen from the side the fourth abdominal segment of the male appears to have on each side of its middle, a strongly elevated narrow ridge, highest towards its base, with its basal end vertical, and with its apex projecting as a truncated tooth beyond the apex of the segment. From an oblique direction each ridge is seen to be distinctly double, with the separate parts conjoined at apex. Seen directly from behind each appears as two narrow vertical teeth.

Phagonophana hirticeps, n.sp.

Moderately dark castaneous, elytra slightly paler, legs slightly paler still, tarsi and palpi almost flavous. Clothing much as in preceding species, except that it is denser on the head.

Head moderately wide. Eyes small, latero-frontal and prominent. Antennae long and rather thin, second joint slightly shorter than first, slightly stouter than third and almost as long as third and fourth combined, third to sixth of even width, the others slightly and regularly increasing in width, eleventh subconical,

slightly longer than ninth and tenth combined. *Prothorax* strongly convex, distinctly longer than wide, widest across apical third; near base with two rounded foveae, the space between almost carinated. *Elytra* with outlines much as in preceding species; a narrow stria close to each side of the suture on the basal fifth; punctures sparse and indistinct. *Legs* long and rather stout; hind coxae rather widely separated. Length, 2 1/6 mm.

Hab.—Tasmania: Southport (A. M. Lea).

In general appearance close to the preceding species, but antennae stouter, elytra less suddenly inflated, and the shades of colour of prothorax and elytra less strongly defined. The separation of the hind coxae is also more noticeable, but the two species are so obviously close together that it is inadvisable to generically separate them, although the separation is certainly more pronounced than in any other species of *Phagonophana*.

Phagonophana crassipes, n.sp.

Colour and clothing as in *abundans*, except that on the head and prothorax the clothing is denser.

Head moderately long, with fairly numerous but more or less concealed punctures. Eyes small, latero-frontal, and moderately prominent. Antennae moderately long and not very thin, joints of subcontinuous width, eleventh joint subconical, as long as ninth and tenth combined. *Prothorax* rather strongly convex, distinctly longer than wide, widest across apical third; base with four strong impressions. *Elytra* at extreme base no wider than base of prothorax, but almost twice as wide across middle, sides strongly and evenly rounded; each side of base with two impressions, appearing confluent from some directions; with small, and rather sparse, more or less obscured punctures. *Legs* long and rather stout; hind coxae almost touching; femora not pedunculate. Length, 1¾ mm.

Hab.—Tasmania (Macleay Museum and H. H. D. Griffith), Hobart, Mount Wellington, in moss (A. M. Lea).

Somewhat smaller than *abundans* and clothing shorter, and elytra more regularly rounded and different at base; the basal impressions on the prothorax are much the same, but they are partially obscured by the clothing. The antennae are somewhat shorter than in the three preceding species, the ninth and tenth joints are fully twice as wide as long, the others gradually decrease in width, so that the third is just perceptibly transverse.

When viewed straight from behind the hind coxae are seen to be slightly separated, but from other directions they appear to be touching.

Phagonophana pedunculata, n.sp.

Of a rather dark reddish-castaneous, abdomen and legs somewhat paler, tarsi and palpi almost flavous. Elytra moderately clothed with not very long, subdepressed, stramineous hairs, denser on head and sides of prothorax; disc of the latter glabrous.

Head moderately wide. Eyes small, latero-frontal and prominent. Antennae moderately long and not very thin. *Prothorax* moderately convex, slightly longer than wide; base with four impressions. *Elytra* at base distinctly wider than prothorax, and almost twice as wide across middle, sides rather strongly and evenly rounded; with moderately sparse and small punctures. *Legs* long and rather thin; hind coxae touching; hind femora pedunculate, the others much less so. Length, $1\frac{1}{2}$ mm.

Hab.—N. S. Wales: Sydney (Macleay Museum), Clarence River (A. M. Lea).

Rather close to the preceding species, but slightly smaller, antennae a trifle longer (although stouter than most species of the genus), prothorax with the basal impressions somewhat different; and legs longer and of different shape.

The third to fifth joints of antennae are of even width, the sixth is a trifle wider, the seventh is rather suddenly, although not much, wider than the sixth, the others feebly and regularly increase in width, so that it is somewhat difficult to decide as to whether the antennae should be regarded as having the joints of sub-continuous width or as having a five-jointed club. The four basal impressions of the prothorax consist of two rather small median foveae, and a longitudinal impression on each side, connecting them all is an impression that appears rather feeble from some directions, but from others appears almost as a deep continuous groove. The elytral punctures, although small, are fairly distinct where the surface has been abraded.

The pedunculate femora, contiguous hind coxae and joints of antennae of subcontinuous width, or almost so, would appear to denote that this species belongs to *Phagonophana*. Two of the main characters, relied upon by King for distinguishing that genus from others, are the biarticulate labial palpi, and mandibles with two teeth and membranous edge; but to see these it is necessary to

mount specimens, after treatment, in Canada balsam, and such treatment destroys specimens for ordinary examination; so that where but few specimens are available it is not advisable to so treat them. While not contending that hidden characters should never be used for the definition of genera, it certainly appears preferable to use such characters as can be made out by the use of an ordinary lens, or by aid of the microscope, without the destruction of type specimens.

Phagonophana parvicollis, n.sp.

Bright castaneous, abdomen tarsi and palpi somewhat paler. Moderately clothed with not very long, subdepressed, stramineous hairs or pubescence, disc of prothorax glabrous.

Head about as long as wide. Eyes rather small, latero-frontal and moderately prominent. Antennae moderately long. *Prothorax* moderately convex, slightly longer than wide; base with four moderate impressions. *Elytra* at base distinctly wider than prothorax, and fully thrice as wide across middle; sides strongly and evenly rounded, each side of base with two impressions; punctures rather dense and distinct. *Legs* long and rather thin; hind coxae touching; four hind femora pedunculate. Length, $1\frac{1}{3}$ mm.

Hab.—N. S. Wales: Sydney, Ourimbah (A. M. Lea).

The prothorax is unusually small in comparison with the elytra, a character which at once distinguishes it from the preceding species.

The elytra have a few rather long hairs scattered amongst the ordinary ones, but they are not very distinct except from the sides. The second joint of the antennae is distinctly longer than the third, the latter is briefly cylindrical, the fourth to sixth are more or less globular, and of even width, the seventh is slightly longer and distinctly wider than the sixth, the others gradually increase in size, and, as also the seventh, are more or less trapezoidal; the eleventh is subconical and distinctly shorter than the ninth and tenth combined. The antennae therefore could fairly be regarded as having a rather loose five-jointed club, although at a glance the joints appear to be of subcontinuous width. The medio-basal impressions of the prothorax are transverse, the lateral ones are oblique, and all are more or less feebly connected together by a transverse impression. The elytral punctures are quite distinct, even before abrasion.

Phagonophana anthicoides, n.sp.

Of a uniform and bright castaneous, tip of abdomen, tarsi and palpi very little paler. With short, depressed, and rather sparse, stramineous hairs or pubescence.

Head distinctly transverse; with a short transverse antennary ridge on each side, and a small fovea behind each ridge. Eyes rather small, latero-median and prominent. Antennae not very long, joints of subcontinuous width. *Prothorax* somewhat depressed, distinctly longer than wide, widest close to apex; base with two small foveae and a more distinct one on each side, although only partially visible from above. *Elytra* depressed, base wider than base of prothorax, but not wider than near its apex, sides moderately rounded and widest at about basal two-fifths; with fairly numerous, and, for the genus, rather coarse punctures on basal half, becoming smaller posteriorly. *Legs* moderately long; hind coxae feebly separated; hind femora decidedly pedunculated, the others much less noticeably so. Length, 1 2/3 mm.

Hab.—N. S. Wales: Sydney, Glen Innes (A. M. Lea).

A depressed species, in general appearance like several species of *Heterognathus*, but the hind coxae are almost touching. The elytral punctures are stronger than in the preceding species. The shape and general appearance are decidedly suggestive of some of the pale species of *Anthicus*.

The second to sixth joints of antennae are of even width, the others regularly increasing in width, but as the ninth and tenth, in addition to being wider, are somewhat longer than the seventh, the antennae might be regarded as having a three-jointed club; the eleventh joint is subconical, and almost as long as the ninth and tenth combined.

Phagonophana ovipennis, n.sp.

Of a rather dark reddish-castaneous, abdomen and appendages somewhat paler, tarsi and palpi almost flavous. Moderately clothed with suberect and moderately long stramineous hairs, becoming dense on sides and base of prothorax, and of head.

Head rather long and thin; with a somewhat obscured depression close to each eye. Eyes small, latero-frontal and moderately prominent. Antennae moderately long. *Prothorax* about once and one-half as long as wide; base with four rather large foveae. *Elytra* elongate-ovate, extreme base the width of prothorax, across middle almost twice the width, sides regularly rounded; punctures small,

sparse and indistinct. *Legs* long and moderately stout; hind coxae lightly separated; femora scarcely pedunculate. Length, 1½ mm.

Hab.—Tasmania: Waratah, in moss (A. M. Lea).

The eleventh joint of the antennae is subconical, distinctly wider than tenth, and about as long as ninth and tenth combined, these are strongly transverse with the ninth narrower than the tenth, the eighth and seventh regularly decrease in width, so that, although the antennae might fairly be regarded as having a three-jointed club, they might just as fairly be regarded as having the joints of subcontinuous width. The basal foveae of the prothorax are rather large and close together, the lateral ones being partially visible from above, but they are all partially obscured by clothing. The hind coxae are so close together that it is only from certain directions that they can be seen to be separated.

This and the following are peculiarly narrow, convex species, and it is possible that they should be regarded as belonging to a new genus, but as their maxillary palpi and hind coxae appear to be as in *Phagonophana*, and as I have seen but a single specimen of each, it is certainly inadvisable to treat them so as to render the mouth parts visible.

Phagonophana tenuis, n.sp.

Bright castaneous, appendages somewhat paler. Rather lightly clothed with short depressed hairs or pubescence.

Head (including neck) about twice as long as wide, with a short transverse antennary ridge on each side in front. Eyes very small and latero-frontal. Antennae moderately long. *Prothorax* distinctly longer than wide, sides lightly and uniformly rounded; base with four small foveae, the median ones rather close together, the lateral ones partially concealed from above. *Elytra* and *legs* much as in preceding species. Length, 1¼ mm.

Hab.—Tasmania: Mount Wellington, in moss (A. M. Lea).

In appearance like a pale miniature specimen of the preceding species, but base of prothorax with smaller foveae, terminal joints of antennae differently proportioned and clothing shorter and sparser, etc.

The antennae should perhaps be regarded as having the joints of subcontinuous width, but if regarded as clubbed it would not be easy to decide whether the club consists of two or of three joints. The eleventh is decidedly larger than usual, being considerably wider than the tenth, and as long as the three preceding com-

bined, the tenth is short, strongly transverse, and distinctly wider than ninth, the latter is moderately transverse and somewhat larger than the eighth.

Coatesia, n.g.

Head small, partially concealed from above. Eyes small, medio-lateral and rather prominent. Antennae moderately long, clubbed at apex. Maxillary palpi apparently three-jointed, but fourth joint small and conjoined to apex of third, causing the latter to appear rather large. Labial palpi minute. *Prothorax* strongly transverse. *Scutellum* minute. *Elytra* wide. *Mesosternum* with an acute intercoxal keel. Metasternum moderately long. Abdomen about as long as meso- and metasternum combined. *Legs* rather long and thin; hind coxae moderately separated; tibiae feebly dilated to apex; tarsi very thin.

The minute species upon which it is proposed to found this genus is much wider in proportion than any other of the family actually known to me, or that I have seen figured. Its prothorax also is without any trace of the medio-basal foveae so common in the family, although the lateral ones are present.

I cannot speak as to its position in the family generally, but amongst the genera occurring in Australia it should be placed next to *Megaladerus*, from which it differs in having prothorax decidedly wide, and hind coxae much closer together.

Coatesia lata, n.sp.

Bright reddish-castaneous, tip of abdomen, tarsi and palpi somewhat paler. Clothed with moderately dense, not very long, depressed stramineous pubescence.

Head across eyes less than half the width of base of prothorax. Antennae passing middle coxae, seven basal joints rather thin, eighth slightly larger than seventh, ninth distinctly larger than eighth, but not very large, tenth transverse, distinctly longer and wider than ninth, eleventh large, wider than tenth, and as long as three preceding combined. *Prothorax* moderately convex, fully twice as wide as long, sides strongly rounded in front and almost parallel towards base, base more than twice the width of apex; hind angles flattened, and each with a vague foveate impression; punctures minute and partially concealed. *Elytra* about once and one-third as long as wide, widest at extreme base, which is closely applied to, and the exact width of base of prothorax, sides feebly

diminishing in width to near apex, and then strongly rounded; each side of base with a fairly large depression; with dense, small and partially concealed punctures. Length, 1 mm.

Hab.—N. S. Wales; Nepean River (A. J. Coates), Clarence River, in flood debris (A. M. Lea).

The elytral punctures, although small, are fairly distinct, where, through abrasion, they can be closely examined.

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ART. XVII.—*Notes on Amycterides, with Descriptions of New Species.*

[PART II.]

BY EUSTACE W. FERGUSON, M.B., CH.M.

[Read November 12th, 1914].

A.—*Notes on the distribution of the subfamily in Victoria.*

The study of the distribution of most of the groups of our Australian insect fauna, is as yet only at a beginning. In the Coleoptera many thousands of species have been described and are being described yearly, and yet, so far, little work has been done towards the correlation of the facts of distribution, their dependence on natural barriers, food supply and other factors. It is true, of course, that much is known about the habits and distribution of many groups; thus the *Carenides*, as also the *Helaeides*, are well known to be interior forms, lovers of the inland slopes and dry plains of the interior, whole other forms such as *Notonomus* and *Cardiothorax* are denizens of the well-watered eastern slopes and coastal scrubs. Viewed thus broadly the *Amycterides* are typical inland forms, rich in species on the mountain ranges, fewer in species, but widely distributed, over the inland plains. It is not my purpose here to discuss in detail the distribution of the subfamily; but certain facts or deductions may be mentioned, in order to facilitate a discussion of the distribution in Victoria. In this connection it may be mentioned that much light will probably be brought to bear on the subject by the application of Mr. R. J. Tillyard's scheme of Specific Contours; so far lack of sufficient data has prevented more than a very general outlining of the contours.

From a consideration of the present distribution it is obvious that, while the subfamily originally developed from a common source, secondary zoocentres have now developed, resulting in several types of distribution, all of them, according to Mr. Tillyard's scheme, entogenic in character.

The genus *Cubicorrhynchus* represents the most generalised type of distribution, it occurs in all the States and appears to be equally

rich in species in all. *Acantholophus* also is generally distributed, but is undergoing development along separate lines in the East and in the West. A second type of distribution is exemplified by the genus *Psalidura;* this has its headquarters, or zoocentre, in the Main Dividing Range of Northern N.S.Wales, spreading thence along the whole eastern mountain system and down the western slopes. *Sclerorinus* is an example of a third type, radiating from a zoocentre in the neighbourhood of the head of Spencer Gulf, in South Australia. A western distribution with its headquarters in the south-west of West Australia probably also exists, the distribution of the "*Euomides*" suggests this; while the genus *Notonophes* suggests the existence of a north-western type.

In turning now to Victoria, it will be seen that its geographical position is between the zoocentres of the second and third types of distribution outlined above. Consequently we would expect to find the predominant species in eastern Victoria closely allied to New South Wales species, and in western Victoria to South Australian species. Unfortunately, as yet, too little detail is known about the habitats and range of many of the Victorian species, to enable an exact determination of their distribution; in the main, however, the species are distributed as above indicated.

Many regions of Victoria, however, appear to have been almost completely neglected from an entomological point of view. This is the more to be deplored, since with the advent of settlement, the breeding grounds are being destroyed, and the extinction of many local forms is not beyond the bounds of possibility.

The distribution of the *Amycterides* in Victoria may perhaps be best approached by a discussion of the distribution of the different genera.

PSALIDURA.—Of the 11 groups into which this genus has been subdivided, but three are known to occur in Victoria.

P. approximata has been recorded from Mt. Buffalo; it is the most southerly representative of the horned-jaw group (mira-group), which extends northward as far as Southern Queensland. It is of interest as being more closely allied to *P. miracula*, which occurs in the Blue Mountains in N.S.Wales than to *P. carteri* (Mt. Kosciusko), or *P. mira* (var. *Edenensis;* Eden).

P. flavosetosa is a species belonging to the candata-group, and appears to have entered Victoria from the west. The candata-group consists, as at present known, of but three species, but these are spread over an immense extent of country, from Central

Queensland to South Australia. The range of *P. flavosetosa* extends from Fowler's Bay in South Australia to the Mallee country in north-west Victoria (Ouyen, Sea Lake).

The bulk of the Victorian species of Psalidura belong to the *mirabunda* group, a group which is typically Victorian though overlapping into surrounding States. *P. mirabunda* is almost certainly the original *Curculio mirabilis* of Kirby, and that name should take precedence; the names *impressa*, *crenulata*, *Howitti* and *Helyi* have already been relegated to synonymy. Tasmania is embraced in the range of the species, and it appears to be common along the southern portions of Victoria; I have records of the following Victorian localities:—Thorpdale, Flinders, Ferntree Gully, Mordialloc, Melbourne and Wallan. Most of the specimens I have seen were labelled merely Tasmania or Victoria. Of its western limit I am uncertain, I have never received it from Portland, but there is a specimen in the National Museum labelled South Australia.

P. monticola was described from specimens taken by Mr. T. G. Sloane at Mt. Buffalo, I have recently received a specimen from Mr. J. E. Dixon from Tallangatta, while specimens in the National Museum are from the Victorian Alps. The range of the species therefore includes the north-eastern mountains, but its limits are at present unknown.

P. cultrata was described from material originally in the Castlenau collection. I have a note that one specimen was labelled Melbourne, but it is strange that I have never seen specimens from another source.

P. Helmsi was described from Benalla (R. Helms).

P. flavovaria occurs at Portland and in South Australia, the specimens from the latter State, that I have seen, were without locality labels. A variety of this species occurs at Mt. Macedon.

The locality of *P. Leai* (herein described) is unknown.

TALAURINUS.—The distribution of this genus has not yet been satisfactorily worked out; probably because the genus, as at present constiuted, is extremely complex and requires subdivision. In the main, however, the tuberculate and costate sections, which comprise the typical species, correspond in their distribution to *Psalidura;* with, in the case of the tuberculate forms, a secondary zoocentre in South-west Australia. The distribution of the granulate forms is much more puzzling; almost absent in N.S. Wales, where the tuberculate and costate forms are most abundant, they are common in Victoria, South Australia, to a less extent in

Western Australia, and common also in Queensland. Of this section of the genus, Victoria possesses 7 species.

T. Riverinae, Macl., enjoys a wide range from the Riverina in New South Wales, through the north of Victoria to Port Lincoln in South Australia; it is common in the Mallee country in Victoria, and probably occurs throughout the country north of the Dividing Range.

T. tomentosus Boisd. occurs along the southern sea-board, from South Australia to Wilson's Promontory; I have also seen it from King Is.

T. penicillatus Macl. is the Tasmanian representative of T. tomentosus, and is rather doubtfully distinct. I have a specimen labelled as Victorian.

T. tenebricosus Ferg. occurs chiefly in the southern portion of the State; it is common about Melbourne, and I have specimens from Benalla.

T. Howitti Macl. also occurs in the neighbourhood of Melbourne.

T. simplicipes Lea was described from South Australia, but is common in western Victoria and as far east as Melbourne.

Of the tuberculate section 8 species occur in Victoria.

T. tuberculatus Macl. occurs in the vicinity of Melbourne. *T. hystrix*, a closely allied species, is herein described as new from Portland.

T. typicus Macl., or a new species closely allied to *typicus*, I have seen from Benalla.

T. acutipennis Ferg., a closely allied species, occurs at Melbourne and Mt. Macedon.

T. melancholicus Lea is also from Mt. Macedon.

The distribution of these species is interesting, as in almost all the cases they are nearly allied to New South Wales form not recorded from the intervening country. Thus *T. tuberculatus* and *T. hystrix* find their nearest allies in *T. verrucosus*, from central eastern N.S. Wales, and *T. halmaturinus* from Kangaroo Island; and furthermore the Kangaroo Island species is more nearly allied to the New South Wales species than it is to the Victorian. *T. acutipennis* is most nearly allied to *T. typicus*, but, as noted above, this species, or one very closely related to it, comes as far south as Benalla. *T. melancholicus* is related to *T. turneri* from Mt. Kosciusko.

T. angustus Ferg. *and T. perplexus*, n.sp., are two closely related forms allied to the *bucephalus* group. *T. angustus* occurs at Mt.

Macedon, Ballarat and Glenample, and probably elsewhere, most of my specimen being labelled Victoria. *T. perplexus* is from Portland.

T. scaber Boisd., an aberrant tuberculate form, occurs inland in Victoria.

The costate section is represented in Victoria by several fine species.

T. impressicollis Macl. (syn. *T. hiscipennis*), I have from Dandenong and Narracan. I believe it also occurs at Warburton.

T. laevicollis Pasc. has a similar distribution, most of the specimens I have seen were labelled Gippsland.

T. costipennis Ferg. occurs among the Dandenong Ranges, and probably near Melbourne; I have never seen it from Mt. Macedon.

T. carinatus Ferg. is found at Portland. It is closely allied to *T. laevicollis* and *T. costipennis*, and also to *T. Kirbyi* from New South Wales.

Scleborinus.—This genus is represented in Victoria by species belonging to 4 distinct groups. The most abundant species belong to the Adelaidae-group; and three species have been described. Of these *S. Howitti* is conspecific with *S. tristis*, while S. *obliteratus* is somewhat doubtfully distinct. But the species of this group present such variation in size and structure that it is extremely difficult to find good specific distinctions. *S. tristis* occurs along the southern sea-board and is also found in Tasmania and South Australia. Of the locality of *S. obliteratus*, I am uncertain, but, if I am correct in my identification, it occurs at Mt. Buffalo and in the Australian Alps.

S. inornatus, n.sp., is closely allied, and is from Gippsland; but a closely related form occurs at Portland. Several other species of this group also probably exist in Victoria, as a number of single specimens have passed through my hands, which I have been unable to certainly identify with any described form.

Including these forms, the group appears to extend over the greater part of Victoria with the exception of the north-west. The group is essentially a South Australian one, and the Victorian species are more numerous in the western part of the State, but follow the mountain ranges right into New South Wales.

The sabulosus group is represented by *S. Dixoni* and *S. Goudiei*, two species herein described, and both closely related to *S. sabulosus*. Of these *S. Dixoni* occurs at Ouyen and Kow Plains, and *S. Goudiei* at Birchip. A third representative of this group is *S. amycteroides*, of which all the specimens I have seen came from Portland.

The vestitus-group has several representatives.

S. vestitus Macl., occurs in the Mallee country, my specimens are from Birchip and Sea Lake.

S. sublineatus also occurs in the Mallee, and I have received it from Melbourne. Both of these species are common in South Australia, they appear to have spread across into the north-west of Victoria, and, so far, I have not seen specimens from the south-west corner of that State.

S. alpicola Ferg. from the Victorian Alps is the southern form of *S. inconstans* Lea, from Mt. Kosciusko.

S. tuberculosus Macl. was described from Victoria, but I am unacquainted with its exact habitat. *S. mucronatus* is probably a synonym.

S. mucronipennis Ferg. occurs at Nelson, in the south-west corner of Victoria. Both of these species are related to *S. Germari* from South Australia, and appear to have spread into Victoria by a more southerly route than *S. vestitus*.

S. dilaticollis Macl. occurs about Melbourne, and *S. bubalus* extends from South Australia to Tasmania. These two species are representatives of a fourth group of the genus, which is now more characteristic of New South Wales than of South Australia.

S. Riverinae Macl., an aberrant species, is widespread north of the Dividing Range and extends into New South Wales.

OPETIOPTERYX.—This genus was described from a single specimen —*O. frigida* Blackb.—taken on one of the higher mountains in the Victorian Alps. The genus is unknown to me, but is probably allied to Sclerorinus.

ACANTHOLOPHUS.—The Victorian species of this genus are more characteristic of the eastern forms than of the western. So far comparatively few species have been recorded from Victoria; doubtless more remain to be discovered.

Ac. spiniger Macl. has a wide range, extending into New South Wales. Of its Victorian range I am uncertain, most specimens I have seen were labelled Victoria. I believe it occurs in the vicinity of Melbourne.

Ac. approximatus is widely distributed. I have or have seen specimens from Bullarook, Ararat, Dandenong Ranges, Gippsland and the Grampians. It is allied to *Ac. Adelaidae* of South Australia.

Ac. Dixoni, n.sp., and *Ac. angusticollis*, n.sp., both herein described, occur at Portland. They probably both belong to the same group.

Ac. squamosus Macl. occurs in the mountains to the north-east of Melbourne. My specimens are from Narbethong, I have seen it also from Warragul.

Ac. sublobatus Macl. was founded on a ♂ of *Ac. squamosus* and a ♀ of *Ac. approximatus.*

Ac. denticollis Macl., or its variety *serraticollis*, occurs in Victoria; I have seen specimens from Benalla.

An undescribed *Acantholophus* is also in my collection from the Victorian Alps.

Ac. brevicornis, herein described, is a geographical race of *Ac. dumosus* Bohem., which occurs at King George Sound in West Australia. *Ac. brevicornis* is from Portland.

Cubicorrhynchus.—This genus is widespread throughout Australia; it is a lover of the slopes and plains, and is rare in the mountain districts. The genus is still in a considerable degree of confusion, and probably Victoria will be found to possess more species than are here noted.

C. maculatus Macl. This species is widely distributed over eastern Australia west of the Dividing Range, and is common inland in Victoria. *C. brevipes* Lea, described as a variety of *C. maculatus* appears also to be common in Victoria.

C. globicollis Lea occurs at Melbourne and probably elsewhere in the State. I have a specimen from Albury in New South Wales.

C. sterilis Pasc., described from Victoria, I have never identified.

Of the *Euomid* genera Victoria has five representatives.

Tetralophus.—Three species at least occur in Victoria. *T. sculpturatus* Waterhouse I have seen from Portland and Melbourne.

T. incanus Pasc., described from Victoria, is unknown to me. The third species is represented by a single specimen in my collection from Portland, it is undescribed. *T. elevatus* Pasc. probably also occurs in Victoria.

Dialeptopus has one representative—*D. ferreus*, described by Pascoe from Victoria; I have not seen a Victorian specimen. The genus is common in South Australia.

Mythites.—Three Victorian species have been described. Of these *M. tuberculatus* Lea appears to be widespread; *M. poropteroides* Lea is from Geelong; while *M. granulatus* Lea is, I believe, found near Melbourne. *Bubaris pithecius*, a New South Wales species, also occurs in Victoria.

Sosytelus rugicollis Lea is another New South Wales species which occurs in Victoria. I have no precise records of the locali-

ties where the Victorian specimens of the last two species were taken

In addition to the above list two others—*Acantholophus convexiusculus* and *Amorphorrhinus australis*—probably also occur, I believe I have seen Victorian specimens, but cannot now trace the record.

Viewing the problem broadly, it appears to me probable that the Amycterid fauna of Victoria has developed as the result of emigration from more than one zoocentre. The genus *Psalidura* has probably spread into Victoria from the north-east. Probably the granulate forms first emigrated and by their isolation in different mountain ranges have now evolved the various species of the mirabunda-group. The costate forms, represented by *P. approximata*, have only reached the north-east corner, while no representatives of the tuberculate forms have yet been recorded. The tuberculate and costate sections of the genus *Talaurinus* appear to have followed similar lines; in the case of the costate forms they have not yet reached into South Australia, though the tuberculate forms have proceeded as far as the south-west of West Australia, where they have evolved a secondary zoocentre.

A second line of invasion appears to have been from the west, and there is some evidence to show that two routes have been followed. The fauna of the Mallee country is typically South Australian, and such forms as *Sclerorinus dixoni* and *Sclerorinus vestitus* are characteristic. The fauna of the south-west contains equally typically South Australian forms, but of a different type, and is exemplified by such forms as *Sclerorinus tristis*, *Sclerorinus mucronipennis* and *Talaurinus simplicipes*. I have written the above with some hesitation, as though familiar with the Amycterid fauna of the Mallee country and of Portland in the south-west, I have seen few species from the mid-western parts of Victoria.

The species of *Cubicorrhynchus* and to a less extent of *Acantholophus* are so widespread that it is difficult now to trace their emigrations. Probably they are representatives of a branch split off before the evolution and differentation of the genera of the Psalidura-Talaurinus-Sclerorinus complex. Too little has been done in regard to the distribution of the Euomid genera to enable one to form an accurate conception of their mode of spread; probably, however, most of the Victorian forms came from the west.

Many points of interest in the distribution of these insects suggest themselves as worthy of further study, but too little is

known at present of local faunas to enable any but very broad lines to be indicated. The correlation of distribution with physiographic features and geological changes also requires investigation. Much interesting is also the question of the invasion of Tasmania by these insects, but that cannot be touched on here.

I have purposely dealt solely with the Amycterides in this discussion, but it is possible that other groups will be found to have followed similar lines of distribution.

In the case of wing insects the factors governing distribution are so different that the result is likely to be quite different. The Amycterides, however, are typically wingless ground forms, which have travelled a long way in a very long time. Possibly a close study of their distribution may enable some light to be thrown on the geological history of our country.

B.—*Descriptions of new species, with some notes on previously described forms.*

PSALIDURA VESTITA, n. sp.

♂ Elongate, elliptical-ovate; size large. Black; rather densely clothed with dingy yellow subsquamose pubescence; clothing more or less uniform above, except on prothoracic granules and elytral interstices; below clothing present on sternal segments, on the first abdominal, at sides of the second, and at bases of the other ventral segments; legs more or less clothed. Setae rather light brown.

Head and rostrum as in *P. Mastersi.* Prothorax (6.5 x 7 mm.) very similar to *P. Mastersi*, slightly more elongate; granules, if anything, slightly smaller. Elytra (14 x 8 mm.) in shape similar to *P. Mastersi;* the foveae regular, somewhat obscured by the clothing, the intervening ridges fairly regular, in the more lateral striae, each ridge with a definite setigerous granule in the middle; interstices subcostiform, with obsolete granules, these becoming more definite on the more laterally placed interstices. Beneath as in *P. Mastersi;* the forceps thin, very similar, slightly more incurved to apex.

♀ Larger and more robust; the prothoracic granules rather coarser; elytral foveae less definite, the intervening ridges setigero-granulate in all the striae. Beneath convex, without anal excavation or forceps.

Dimensions.—♂ 23 x 8 mm.; ♀ 25 x 9.5 mm.

Except for the clothing, there is nothing to distinguish the present species from *P. Mastersi.* The clothing is, however, quite distinc-

tive and appears to be constant. The contrast between the rather nitid *P. Mastersi*, with hardly a vestige of clothing, and this dull, densely clothed species is too great to allow me considering them as otherwise than specifically distinct.

The type ♂ is from Richmond Downs, Queensland, and is in the collection of the Queensland Museum; the type ♀ in my own collection, and a second ♀ in the National Museum, Melbourne, came from Mr. C. French, and are labelled Queensland, without a definite locality.

PSALIDURA LEAI, n. sp.

♂ Elongate, subparallel. Black, legs diluted with reddish; clothing absent; setae black, decumbent.

Head strongly convex, partially concealed by prothorax, moderately closely setigero-punctate. Rostrum very short, wide; internal ridges prominent, somewhat convergent, separated at base by a distinct median notch; median area strongly depressed in front; sublateral and basal sulci continuous, rather deeply impressed. Submentum with median tooth, forwardly directed. Prothorax (6 x 6 mm.) evenly rounded on sides, median lobe produced over head to some extent; subapical construction faint but traceable; disc somewhat flattened, with median line feebly impressed; closely set with small, rounded, contiguous, setigerous granules, these somewhat smaller towards centre. Elytra (13 x 8 mm.) evenly rounded from behind base to apex, apex abruptly rounded, mucronate at suture; humeral angles thickened, out-turned. Disc foveo-striate; striae moderately deep; foveae small, punctiform, slightly transverse, and ill-defined, ridges between foveae little raised, each with a fine setigerous granule; interstices moderately prominent, the third and fifth slightly more so, set with small depressed umbilicate setigerous granules, in double, frequently in triple, series, on the fourth and sixth in single series, duplicated in the middle. Metasternum transversely concave, more deeply depressed in middle along intercoxal process; at sides on a level with middle coxae. Fifth segment strongly excavate, anterior wall of excavation almost vertical; excavation reaching to anterior margin of segment in the middle; preanal fossa deeply set, slightly transverse. Fascicles moderately large, separated about 1.5 mm. Forceps longer than in *P. cultrata*, projecting beyond apex of elytra when not extended, broad at base, gradually narrowing beyond insertion of laminae; apex somewhat obtusely pointed; with a ridge or setose hair down centre of inner surface. Laminae inserted behind setose

ridge, very long, parallel-sided, apices broadly rounded; slightly curved inwards. *Dimensions:* ♂ 20 x 8 mm. *Hab.*—Victoria? Type in A. M. Lea's collection.

Close to *P. cultrata* but distinguished by its longer forceps; there are also differences in the elytral sculpture. In *P. cultrata* the length of the forceps beyond the insertion of the laminae is 1.5 mm., in *P. Leai* 2.5 mm. In the type the genitalia are partly extruded and in consequence the laminae overlap, in another specimen the genitalia are at rest and the apices of the forceps merely touch. In my table this species would fall beside *P. Sloanei*, but the absence of clothing together with shape of the forceps, not twisted, will separate it.

TALAURINUS.

Through the kindness of Mr. K. G. Blair of the British Museum, who, at my request, made an examination of Bohemann's types in the Hope Collection, I am now able to clear up the question of the identity of the species comprised in the *semispinosus*-group. The species constituting that group are all very closely allied and also very variable, so that it is difficult to find reliable features for separating the species. It is quite possible that some of these species, here regarded as distinct, are not really so; but I think it advisable to attach names to the most distinctive types, although in some cases there may be intermediate forms tending to link them up. The puncturation of the external rostral ridges and of the head, I have found of some importance. The clothing is on the whole fairly constant. The tuberculation, both of the prothorax and elytra, though to a certain extent variable, can also be made use of.

Talaurinus Roei Bohem. This is not the species redescribed by me, but is identical with *T. funereus* Pascoe. It differs from all others of the group in the much more closely and rugosely punctate head and external rostral ridges, the latter being distinctly convergent posteriorly. The head and rostrum, as viewed in profile, are not in the same plane above; the prothorax is closely and finely granulate; the elytra have the tubercles more acute, and more spinelike, than in any other of the group. Of this species I have an extensive series taken by Mr. H. J. Carter at Gingin, Western Australia, and it is not too much to say that no two specimens are alike. The chief variation is in the number of the elytral tubercles; the head and rostrum and the prothorax are constant in their sculpture.

Talaurinus semispinosus Bohem.; *T. pastillarius* Bohem.; *T. pustulatus* Pasc. From Mr. Blair's notes these names appear to belong to but one species. It is perhaps the commonest species in Western Australia, and is very variable. The type of *T. pastillarius* was not examined, this should be in the Stockholm Museum; but specimens so labelled in the Hope Coll., were considered by Mr. Blair to be conspecific with *T. semispinosus*. The puncturation of the rostral ridges is fairly close, but not as in *T. Roei*. The prothorax is fairly closely granulate, but is variable in this respect, the median granules, or tubercles, in some specimens being more spaced out and slightly transverse. The elytral tubercles are variable in number, and also in size, particularly on the more lateral interstices; as a rule they are of moderate size, and the apical and lateral ones subconical.

T. simulator Pasc. Compared with the last species *T. simulator* has the tubercles rounded, shiny, and more numerous on the fourth and fifth interstices. Specimens identified for me by Mr. Blair have the head and rostral ridges almost impunctate, only a few obsolete punctures being traceable. My specimens came from Kellerberrin, Western Australia. Other specimens from Eucla and Eyre's Sandpatch are smaller and possibly distinct.

Talaurinus echinops Pasc. Though described as a *Sclerorinus*, this species is certainly congeneric with *T. semispinosus*. It is a more densely clothed species, with more numerous tubercles. The head and rostral puncturation is much as in *T. semispinosus*, and the prothoracic granules are small and closely placed. In general appearance it is not unlike *T. Roei*, but the head and rostrum are in the same plane above, the rostral punctures are different, and the elytral tubercles are stouter.

T. validus, n.sp. This species may be distinguished by its strong elytral tubercles, much larger than in *T. semispinosus*. The punctures of the head and rostrum are obsolescent. The prothoracic tubercles are large and widely separated.

Talaurinus Leai, n.sp. Close to the last species and with similar strong elytral tubercles, it differs in the more closely punctate head and rostrum, and in the smaller, much more closely placed prothoracic tubercles.

Talaurinus Westwoodi Bohem. The type of this species was also examined by Mr. Blair, and it proves to be synonymous with *T. bucephalus* Olivier.

Talaurinus excavatus Bohem. Mr. Blair has kindly sent out specimens compared with the type in the Hope collection. It is the

species I have re-described as *T. rugifer* Boisd. I have now little doubt that this synonymy is correct.

SCLERORRHINELLA.

S. Manglesi Bohem. Mr. Blair has examined the type, and has determined my specimen as correctly named.

S. melanopsis Pasc. A specimen compared with the type of *T. melanopsis*, has been sent out for examination. It is certainly a *Sclerorrhinella* and distinct from *S. Manglesi*. The species may be recognised by its strong closely set elytral tubercles, and by its lack of clothing. The specimen sent is a male, and measures 14 x 6 mm.

TALAURINUS GRANULATUS, n. sp.

♂ Ovate, general facies that of *T. Riverinae*. Black; densely clothed above with brown subpubescence; head and prothorax trivittate, elytra irregularly maculate with white, the white clothing predominating on sides; ventral segments feebly maculate with yellowish setae in centre and with white laterally; legs mottled white. Setae dark brown. Head and rostrum as in *T. Riverinae*. Prothorax (3.5 x 4.5 mm.) rotundate; with deep post ocular emargination and prominent ocular lobes; closely set with small, but prominent, rounded, umbilicate, setigerous granules, partially concealed by clothing, and larger than in *T. Riverinae*. Elytra (9 x 7 mm.) rather widely ampliate, strongly declivous posteriorly; apex subtruncate; base gently arcuate, the humeri marked by a small granule, not prominent. Disc puncto-striate, the punctures shallow, indefinite, intervening ridges low, each with a small setigerous granule; interstices closely granulate throughout in single series, the granules prominent, umbilicate, partially obscured by clothing, larger than in *T. Riverinae*. Undersurface as in *T. Riverinae*.

♀ More elongate-ovate; the undersurface convex, fifth segment with a slight transverse impression near middle, not excavate.

Dimensions.— ♂ 13 x 7 mm.; ♀ 14 x 6 mm.

Hab.—Purnong R., Murray River, South Australia (S. W. Fulton). Type in National Museum, Melbourne. Close to *T. Riverinae*, but with the granules both on prothorax and elytra evidently larger than in that species.

TALAURINUS SIMPLEX, n.sp.

♂ Small, elongate-ovate, in general facies like *T. maculipennis*. Black, densely clothed with greyish subpubescence, prothorax trivittate, elytra maculate with lighter grey. Setae bright yellow.

Head and rostrum much as in *T. maculipennis;* antennal scape long. Prothorax (3 x 4 mm.) rounded on sides, apical margin feebly rounded above, with moderately definite post ocular emargination; subapical construction moderately well marked; closely set with small, rounded, setigerous granules, sides also granulate. Elytra (7 x 5 mm.) elongate, at base not quite so wide as prothorax, gradually widening backwards; base generally arcuate; humeri not produced. Disc with series of small shallow foveiform punctures, the intervening ridges setigerous, not definitely granulate; interstices with small obscure setigerous granules in single series; sides with granules obsolete. Intermediate ventral segments rather long; apical segment with a broad shallow depression in middle, running into a deeper transverse sulcus, depression bounded on either side by a strongly raised somewhat obliquely set ridge or tubercle. Tibiae simple, without subapical emargination. *Dimensions:* ♂ 12.5 x 5 mm.

Hab.—South Australia, Warburton Ranges (Hacker); Ouldea (South Australian Museum). Type in A. M. Lea's collection.

In general appearance remarkably close to *T. maculipennis*, but readily distinguished by the simple tibiae. *T. simplicipes* is a shorter insect with different rostral sculpture, shorter and stouter antennal scape and different apical excavation. *T. Howitti* also differs in the structure of the excavation. *T. flaveolus*, inter alia, has very different clothing and an almost obliterated elytral sculpture. This species was amongst the Amycterides in the South Australian Museum, but was not described as new until it could be compared with *T. carbonarius;* Mr. Blair of the British Museum his since informed me that it is not that species.

TALAURINUS PERPLEXUS, n. sp.

♂ Size moderately large, elongate-ovate. Black; densely clothed with obscure, mingled brownish and golden, subpubescence; feebly trivittate with light grey on prothorax, vittate along disc of elytra, internal to fifth interstice; ventral segments maculate in middle with yellow, forming an almost continuous vitta. Setae dark, reddish brown.

Head continuous in profile with the rostrum; forehead feebly flattened. Rostrum moderately deeply excavate; external ridges subparallel; internal ridges prominent, long, slightly convergent, not meeting; median area moderately deeply depressed, narrow, sulciform; sublateral sulci long, moderately deep. Scrobes open posteriorly. Eyes large, ovate. Antennal scape moderately long. Prothorax (3.75 x 4 mm.) little wider than long, rather feebly rounded on sides; apical margin rounded above, with moderately marked postocular emargination, but with lobes indefinite; transverse subapical impression well marked, median impression feeble, more marked posteriorly. Disc rather closely set with small round granules, smallest about centre, larger along subapical impression; sides also granulate. Elytra (11 x 6 mm.) elongate, at base as wide as prothorax, gently widened from base backwards; base gently emarginate, humeri very slightly produced. Disc with punctures indefinable, but with intrastrial granules distinct, often confused with the interstitial tubercles; interstices with small tubercles, for the most part hardly larger than granules; second with about eight isolated ones, small at base; becoming larger posteriorly, one or two being on declivity; third with small granuliform tubercles, irregularly arranged in double series from base to middle, thence in single series, tubercles not reaching to apex; fourth with one or two small tubercles about middle; fifth with tubercles similar to third but inconstant in arrangement, basal tubercles generally in double series; sixth with a single row of from six to ten small tubercles, not extending to base or apex. Sides with interstitial granules in single series. Beneath flat; intermediate segments long; fifth segment with a feeble subquadrate impression, with a small tubercle on either side near apex, partly obscured by setae.

♂ Rather more ovate than ♀; elytral sculpture similar, but even more confused; beneath gently convex, fifth segment without impression.

Dimensions.— ♂ 17 x 6 mm.; ♀ 17 x 6.5 mm.

Hab.—Victoria, Portland (J. E. Dixon, also from National Museum and British Museum).

Of this interesting species, I have recently received 26 specimens, from J. E. Dixon, of Melbourne. Though I believe it to belong to the tuberculate section of the genus, the tubercles are so fine as to be mere granules. It is most nearly allied to *T. angustus*, also a Victorian species, and the elytral tubercles are fine in both species, but the differences in arrangement, and especially the conspicuous

intrastrial granules, will not permit me regarding them as conspecific. I have described the clothing from a specimen in good preservation, most of the series before me, however, have a more or less uniform, dingy clothing. The elytral sculpture varies considerably, particularly in regard to the degree of duplication of the tubercles on the third and fifth interstices. On the fifth the basal tubercles, for perhaps a quarter of the length of the interstice, are generally arranged, sometimes in single, sometimes in double series, in a slight arc, with convexity outwards; the succeeding tubercles are in a more or less straight line, sometimes in single series throughout, sometimes in irregular double series, for another quarter of the length of the interstice; the remaining portion is always tuberculate in single series.

Type in author's collection.

TALAURINUS HYSTRIX, n. sp.

♂ Size moderately large, elongate, suboblongate. Black, without clothing; setae black.

Head convex; forehead slightly depressed in front, the depression bounded on either side by a short ridge, the continuation backwards of the external rostral ridges. Rostrum short, deeply excavate; external ridges prominent; moderately closely setigero-punctate; internal ridges obsolete; median area not raised; sublateral sulci, short, subtriangular, foveiform, situated at extreme base of rostrum and connected across base. Scrobes open behind, reaching almost to eyes. Eyes subovate, almost rotundate. Prothorax (5 x 6 mm.) rather strongly dilate; apical border with moderately prominent ocular lobes. Disc strongly convex transversely; subapical construction barely traceable; without median impression, but with indefinite sublateral impressions; moderately closely set with rather strong, rounded tubercles, smaller in immediate centre, and also along sublateral impressions. Sides with granules obsolete. Elytra (11 x 7 mm.) not greatly widened on sides; base arcuate, humeri marked by outwardly projecting tubercles. Disc without evident punctures, but with numerous conspicuous granules, not definitely traceable into series; interstices strongly tuberculate, tubercles subconical basally, large and acutely conical, almost spinose, posteriorly and laterally; sutural interstices with a row of fine granules, and a few larger confluent ones at base; second with, as a rule, from two to four (in type-form), about middle; third with a row from base to halfway down declivity, varying from six to

eleven in number; fourth with from one to three, anterior to middle; fifth with from five to nine; sixth with from six to eight strong, more outwardly directed, tubercles. Sides with tubercles subobsolete. Apical ventral segment with a median excavation, subdivided into two deeper, suboval, longitudinal depressions, by a somewhat raised median ridge, fringed at extreme apex with dense hirsute setae; with a small tubercle on each side of the excavation near apex, slightly projecting over excavation. Anterior femora with a short ridge on the lower surface.

♂ In appearance and sculpture very similar to male; slightly more ovate; beneath convex, fifth segment with a ∧ shaped impression, enclosing a somewhat raised, rather closely punctured area.

Dimensions.— ♂ 17.5 x 7; ♀ 17 x 7 mm.

Hab.—Victoria, Portland (J. E. Dixon).

Of this fine species I have before me a series of 60 specimens, all sent by Mr. J. E. Dixon. This long series has enabled me to take into consideration questions of variation in size and tuberculation. In regard to size there is not an extreme range, the smallest male measures 15 x 6 mm., and the largest female 18 x 8 mm.

I have given the general range of the number of tubercles on each interstice in the description, but as a rule the highest and lowest numbers are exceptional. In regard to the second interstice, occasionally five tubercles may occur, while in one specimen there are none on that interstice. In the type ♂, on the second interstice immediately above the apex, occurs a short tubercle or spine; this is as a rule absent, being present in only 12 out of 60 specimens, and in 6 of these it occurs on one side only. It is not a sexual character, though the tubercles seem to occur rather oftener in the male.

Of previously described species, the present one is most closely allied to *T. tuberculatus*, Macl. The apical excavation is similar in type in the two species; in *T. tuberculatus*, however, it is wider, and the secondary depressions are farther apart, and not so deep. Apart from the anal excavation, however, *T. hystrix* differs from *T. tuberculatus* in its relatively short, more robust form, and in the complete absence of the variegate clothing so characteristic of *T. tuberculatus*.

TALAURINUS LEAI n. sp.

♂ Large; elongate, subparallel. Black, without clothing above, a narrow line of silaceous scales on each side of median line and marginal plate of rostrum. Setae black.

Head and rostrum continuous above in profile; forehead slightly depressed at base of rostrum; head and rostrum moderately closely punctate, punctures distinct, rounded, nowhere confluent, coarser and rather closer together on rostrum. Rostrum excavate, external ridges subparallel; median area not raised, but with a narrow median laevigate line; internal ridges obsolete; latero-basal sulci subtriangular, deep, foveiform. Prothorax (5.5 x 7 mm.) rather strongly ampliate, widest in front of middle; apical margin with post-ocular emargination but with lobes indefinite; subapical constriction indistinct. Rather closely set with moderately small rounded granules, slightly larger along constriction, and very feebly transverse in middle; sides granulate. Elytra (12 x 7 mm.) subparallel; humeri strongly tuberculiform, outwardly projecting; base between humeri gently concave, and with thickened basal border, absent in middle; derm granulate-punctate between the tubercles, no definite arrangement into striae. Tubercles strong, acutely conical posteriorly, less prominent, somewhat elongate on the second and third interstices at base; second with six, not extending down declivity; third with eight, at intervals, from base to apex, the last two or three on declivity in line with second interstice; fourth without tubercles; fifth with eight, at intervals, from base down declivity; sixth with six, rather closer together, strongly conical and outwardly directed; lateral interstices nodulose. Ventral segments flattened; basal segments finely strigose, suture between them depressed; intermediate segments smooth, rugosely punctate at sides, less so in middle; apical segment rugosely punctate, with a feeble triangular depression at apex, slightly deeper along posterior margin, depression with short, thick, setose hair. Anterior femora with a feeble ridge beneath.

♀ More ovate; convex beneath; apical ventral segment with a short transverse impression at apex.

Dimensions: ♂ 20 x 7 mm.; ♀ 18 x 7 mm.

Hab.—West Australia, Swan River, Darling Ranges.

Type in A. M. Lea's collection.

Closest to *T. semispinosus* but considerably larger, more parallel, with considerably stronger tuberculation of elytra. The prothoracic granules are about the same size, but not quite so depressed, and the prothorax is notably larger and more transverse. The rostral punctures—a fairly constant feature in this group—are similar.

TALAURINUS VALIDUS, n. sp.

♀ Large, robust, elongate-ovate. Black, dull; practically without clothing above; sides of elytra maculate with white in depressions.

Head convex, front shallowly concave, in middle slightly raised; profile of head continuous with that of rostrum. Rostrum short, excavate; external ridges subparallel, continued on to head, bordering the concavity; median area sublaevigate, not raised; internal ridges obsolete; lateral basal sulci short, deep, triangularily foveiform, not meeting across base; punctures of head and rostrum obsolescent. Scrobes open posteriorly. Eyes small, subrotundate. Prothorax (5.5 x 7 mm.) widest somewhat in front of middle; apical margin with moderately deep postocular emargination; subapical impression not clearly defined; disc convex, set with large, isolated, rounded tubercles, the central ones very slightly transverse. Sides with tubercles smaller. Elytra (14 x 9 mm.) evenly and gently rounded on sides; apex moderately strongly rounded; base rather strongly emarginate, the humeri strongly produced, tuberculiform, the basal margin thickened on each side of suture owing to the confluence of the basal tubercles of the second and third interstices. Disc of elytra granulose between the tubercles, punctures not definitely traceable. Suture with small granules, obsolete posteriorly, becoming larger towards base and merging into basal border on either side, leaving a marked depression at junction of suture with base. Other interstices strongly tuberculate, tubercles large, separate, rounded anteriorly, becoming conical posteriorly and laterally; second with five from base to edge of declivity; third with nine, from base practically to apex, the last two or three on declivity, approximated towards middle, so as to be almost in line with second interstice; fourth with one on basal border, and one or two nearer middle of interstice; fifth with strong humeral tubercle, and six strong conical tubercles, extending down declivity; sixth with seven strong conival tubercles, outwardly directed. Sides with depressions more defined and arranged in series, the interstices nodulose. Beneath convex; depressed along suture between first and second segments, basal segments minutely transversely strigose; fifth segment with shallow transverse impression at extreme apex.

Dimensions.—♀ 21 x 9 mm.

Hab.—West Australia, Esperance Bay, Swan River.

Type in A. M. Lea's collection.

Allied to *T. semispinosus* but with larger and much stronger tubercles, particularly on the prothorax and on the more lateral elytral interstices. It is possible that a long series of *T. semispinosus* might show forms linking up the two species, but even in that case I think this form well worthy of a distinctive name.

TALAURINUS CARINATIOR, n. sp.

♂ Large, elongate-ovate. Black; rather densely clothed, except on costae, with minute, muddy-grey subpubescence, hardly squames; median ventral vitta dark brown; setae black.

Head convex, slightly ridged on either side in continuation of the external rostral ridges; forehead feebly depressed in front. Rostrum excavate; external ridges somewhat nodulose, traversed by two slight transverse impressions, and separated from head by slight impression; internal ridges less prominent than external, convergent, apices not quite meeting; median area depressed; sublateral sulci narrow, rather shallow, running into transverse depression at base of rostrum. Scrobes ending far from eyes. Eyes ovate. Prothorax (5 x 5 mm.) little widened on sides; apical margin feebly rounded above, with slight post-ocular emargination. Disc with an ill-defined, transverse, subapical constriction, and rather broad median area, free from granules; with rounded granules, moderately large, not closely set, varying in size; tending to run together on either side of median line; sides granulate. Elytra (14 x 8 mm.) elongate-ovate, widest behind middle, apex rounded, feebly mucronate at suture; base gently arcuate, humeri thickened, somewhat out-turned. Disc with three broad sulciform striae, each composed of a double series of foveae; in each series foveae small, rather shallow, not confluent with those above or below, less marked off from, though not absolutely confluent with, those of the adjacent series. Interstices two, four, and six not raised; three, five and seven strongly raised, costiform; sutural less prominent with a row of more or less confluent granules, more strongly costate at base; third very strongly raised and costiform, narrow, somewhat crenulate; fifth almost as strongly raised as third; seventh showing some tendency to resolve into its component granules. Sides foveo-striate in single series; interstices with subobsolete granules. Intermediate ventral segments long; fifth with shallow median depression, and a more strongly depressed pit at extreme apex. Anterior femora simple. *Dimensions:* ♂ 22 x 8 mm.

Hab.—New South Wales, Coramba (W. Heron per H. J. Carter). Type in author's collection.

Close to *T. niveo-vittatus*, but differing in the colour of the clothing; the prothoracic granules are also smaller and less confluent, and the elytral interstices narrower, more raised and less crenulate.

TALAURINUS POSTICALIS, n. sp.

♂ Elongate, narrow, size moderately large. Black, with muddy-grey clothing in depressions, giving insect a dingy appearance. Setae few, mostly absent from elytra, of a light brownish colour. Beneath with a broad, golden-brown, hirsute vitta, extending the length of abdomen.

Head and rostrum in the same plane above; forehead feebly concave. Rostrum moderately long, deeply excavate, external ridges with a light sinuation about middle, slightly thickened at base; internal ridges short, little prominent, convergent but not meeting; median area deeply depressed, sulciform posteriorly, widening out in front; sublateral sulci short, not very deep, running into depression at base of rostrum, behind the internal ridges. Scrobes simple, ending far from eyes. Eyes ovate. Antennal scape moderately long, rather strongly incrassate, slightly curved backwards. Prothorax (4.5 x 4.5 mm.) subcylindrical, little rounded on sides; apical margin lightly sinuate above, more deeply at sides; subapical impression ill-defined, irregular; disc with irregular depressions and nodulose, irregular, confluent elevations, and more definitely granules laterally; sides with flattened granules. Elytra (11 x 7 mm.) slightly wider at base than prothorax, thence evenly and gently rounded on sides; base lightly emarginate, humeri marked by thickened nodule. Disc with three broad foveolate sulci, foveae extremely irregular and ill-defined, not marked off from each other laterally, but separated at irregular intervals above and below by irregular thickened ridges; the outer sulcus with foveae smaller, more punctiform but still ill-defined. Interstices two, four and six quite obsolete, the others costiform; first not elevated except at bottom of declivity, where it is raised into a strong rounded ridge; third interstice very prominent and costiform, somewhat flexuous in outline, extending from base to halfway down declivity; fifth somewhat less elevated, showing a slight tendency to break up into its component granules, extending from humeral angle to edge of declivity; seventh forming lateral boundary, costiform, less prominent, also showing tendency to break up into granules. Sides foveo-striate, foveae small, punctiform; interstices slightly elevated, hardly costate, and not definitely granulate. Beneath with ventral

segments long; fifth segment with a median depression, obscured by vitta. Anterior femora simple. *Dimensions:* ♂ 19 x 7 mm.

Hab.—New South Wales, Coramba (W. Heron per H. J. Carter.)

A typical member of the costate section, I know of no other species with which I can compare it except *T. crenulatus.* From that species it differs in its much larger size, and different clothing, *inter alia multa.* In general appearance it is not unlike a species of *Mythites*, but it is a typical *Talaurinus*.

Type in author's collection.

SCLERORINUS DIXONI, n. sp.

♂ Elongate, large. Black; densely clothed with golden brown squamose subpubescence, prothorax feebly trivittate with lighter, elytra with a few whitish maculae; median ventral vitta dark golden-brown; setae dark.

Head and rostrum as in *S. sabulosus.* Prothorax (7 x 8 mm.) widely ampliate; apical margin lightly rounded above, with rather deep post-ocular emargination; subapical impression rather well marked; median line free from granules but not deeply impressed, disc set with small, more or less round, granules, smaller in centre, somewhat flattened, and variable in size and to some extent in shape. Sides with granules becoming progressively smaller towards coxae, but not obsolete except posteriorly. Elytra (15 x 8 mm.) elongate, very little widened on sides, narrowed to apex from level of declivity, apex rounded; base feebly arcuate, humeral angles marked by a small tubercle; seriate punctures small, obscure, each subtended by a small, but definite, setigerous granule; interstices tuberculate, sutural with small granules, somewhat larger near base; second with three or four small isolated tubercles; third with a continuous row of about twenty-one small tubercles, or granules, feebly subconical, slightly more so posteriorly, closely set, and extending from base almost to apex; fourth with one or none; fifth and sixth each with a continuous row of about sixteen similar to third; lateral interstices with small tubercles, not at all prominent. Beneath as in *S. sabulosus.* Anterior femora ridged beneath.

♀ Shorter and more ovate than the ♂; prothorax slightly less ampliate; elytra with tubercles more numerous and rather smaller, second with six, third with a continuous row as in the ♂, but a number of the middle tubercles duplicated, fourth with five, fifth with twenty, sixth with sixteen.

Dimensions.— ♂ 23 x 8 mm.; ♀ 22 x 9 mm.

Hab.—Victoria, Ouyen (J. Dixon, Searce, Mellor), Kow Plains.

Of this species I have seen a large number of specimens sent to me by Mr. J. Dixon and by the National Museum. All of the specimens agree in having constantly small tubercles, noticeably smaller than in *S. sabulosus.* From that species it also differs in the different clothing and in the more granulate sides of the prothorax. The median vitta in the ♂ is also narrower and darker. The differences in the elytral granulation are more marked between the females of the two species, than in the case of the opposite sex.

Type in author's collection.

Sclerorinus Goudiei, n. sp.

♂ Close to *S. Dixoni* and with similar clothing.

Head, rostrum and prothorax as in *S. Dixoni.* Elytra (15 x 8 mm.) with tubercles notably larger than in *S. Dixoni* (also larger than in *S. sabulosus*), the number of tubercles on the interstices 2 to 6 being 5, 21, 3, 17, and 16, on the left side of the type; on the third interstice tubercles becoming slightly transverse, the posterior ones conical. Otherwise as in *S. Dixoni.*

♂ Differs from ♀ in usual manner; compared with female of *S. Dixoni*, the tubercles are noticeably larger, fewer in number and not duplicated on the third interstice, and with none on the fourth.

Dimensions.— ♂ 23 x 8 mm.; ♀ 22 x 9 mm.

Hab.—Victoria, Birchip (J. C. Goudie).

Type in author's collection.

Though compared with *S. Dixoni*, I regard this species as close to *S. sabulosus.* It differs from the latter in the larger elytral tubercles of both sexes, as well as in the clothing and sides of prothorax. Three specimens from the National Museum labelled Western District should perhaps be regarded as distinct. They differ in the elytral tubercles being slightly larger and fewer in number on the third, fifth and sixth interstices, the tubercles are also rather more conical. The tubercle index is.— ♂ 5, 15, 5, 13, 11; ♀ 6, 17, 4, 16, 13. Their dimensions are.— ♂ 22 x 7.5 mm.; ♀ 22 x 9 mm. At present I think it better to consider these as forms of *S. Goudiei.*

Sclerorinus inornatus, n. sp.

♂ Elongate-ovate, rather small. Black, legs diluted with red; above moderately densely clothed with minute, black subpubescence, and with long, black setae; beneath with scattered, black setae.

Head gently convex above, continuous with rostrum. Rostrum little excavate; external ridges subparallel; median carina distinct, continued as a bare line up forehead, point of junction marked by a round, punctiform fovea; lateral-basal sulci triangular, moderately deep. Scrobes simple. Eyes ovate. Prothorax (4 x 4 mm.) little rounded on sides; apical margin slightly sinuate above, with deep post-ocular emargination. ocular lobes well defined. Disc with moderately distinct subapical constriction and rather indistinct median line; almost smooth, except for some nearly obliterated longitudinal setigerous ridges; sides obsoletely granulate above. Elytra (9 x 6) gently widened on sides; base subtruncate, humeral angles subrectangular, not prominent; disc convex, strial punctures obsolete; interstices feebly raised, with a few isolated, almost obliterated, tubercles, on third interstice extending down declivity; sixth interstice with tubercles smaller, slightly more definite and much closer together. Sides with seriate punctures more evident, interstices with almost completely obsolete granules, closely set, and indicated mainly by the setae. Beneath laevigate, with scattered setigerous punctures. Apical segment with a shallow, rather broad, median, channel, but without tubercles. Anterior tarsi with three basal segments transverse, the second and third spongiose beneath except along median sulcus; intermediate and posterior tarsi with segments more elongate, not spongiose.

♀ Somewhat larger, more ovate, more produced at apex, the elytra separately acuminate; sculpture similar, but interstices not raised, and tubercles slightly more distinct. Beneath convex; apical segment with a narrow median impression, not quite reaching anterior margin, deeper posteriorly; apical margin raised and bisinuate in middle. Anterior tarsi not spongiose.

Dimensions.— ♂ 15 x 6; ♀ 16 x 7 mm.

Hab.—Victoria, Gippsland (C. French).

Types in National Museum, Melbourne.

Two males in the museum collection, from Portland and Western Districts, differ in the lighter, more brownish, clothing, and in the less obliterated sculpture.

The species is undoubtedly close to *S. obliteratus*, but, if I am correct in associating that name with a species found in the Victorian Alps, the present species is readily separated by the apical ventral segment being without tubercles in the male. The sculpture is also more obliterated in *S. inornatus*, compared with the type ♀) of *S. obliteratus*.

ACANTHOLOPHUS DIXONI, n. sp.

♂ Elongate, suboblongate, flattened above; size moderately small. Black. Moderately densely covered with dark grown subsquamose clothing; with a light grey median vitta, and squames of similar colour, lightly scattered on the more lateral elytral tubercles; with white almost silvery squames, forming two small maculae on the sides of the prothorax, and forming a moderately distinct vitta, with a few macules above it posteriorly, on the sides of the elytra; beneath with greyish squames lightly sprinkled over metasternum, and at sides of ventral segments; legs with similar squames, and with a moderately distinct whitish band, about one-third from the apex of the femora.

Rostrum short, the upper surface feebly concave, almost flat, with a median fovea or pit; lateral margins little raised, not tuberculate or angulate in front, gently convex in profile and continued back to supraocular crests. Head with a single crest over each eye, strongly curved backwards and upwards, the apex sharply pointed; the crest joined at base across head by a strong ridge, with a median ridge running forward from it, and almost immediately bifurcating, the limbs running forwards and outwards to join the lateral rostral margins near the base, and enclosing with them a deep fossa on each side. Forehead concave behind the ridge joining the crests. Scrobes short; a deep groove running up from in front of eye, on to the side of the crest. Prothorax (3.5 x 4.5) slightly emarginate behind eyes, ocular lobes rather feebly developed. Disc with a strong transverse impression behind apex, and a similar one immediately in front of base; with median and lateral groups of tubercles on each side; with median area longitudinally furrowed. Median tubercles moderately large, about six on each side, the apical pair larger, more elongate, situated in front of subapical impression, the other tubercles varying in size, not all in line, the third from the front situated further out than the others. Lateral tubercles large, flattened above, obtusely pointed, outwardly directed, with a feeble inclination backwards; consisting of three larger and a few smaller tubercles; two of the larger tubercles situated in front of middle and conjoined at base, the hinder of the two the larger, the third large tubercle situated behind middle, smaller than the larger of the two anterior tubercles; a small tubercle situated anterior to subapical impression, one situated between and below the larger tubercles, and two situated posteriorly. Sides somewhat rugosely strigose. Elytra (8.5 x 5 mm.) little wider

than prothorax; little rounded on sides. Disc with three rows of spinose tubercles, the intermediate interstices rather coarsely granulate, suture granulate, the granules not extending down declivity; first row with eight or nine tubercles, the basal ones small, rounded, becoming progressively larger, the last three or four spinose, the last one the largest; second row not quite reaching to base, running obliquely backwards and outwards, about seven to eight in number, the tubercles small at base, becoming progressively larger and more spinose, the last four or five strong, outwardly directed, spines, reaching slightly beyond first row; third row extending from shoulder back, with a slight inclination outwards, consisting of five large, outwardly directed, spines, the basal two more or less conjoined, larger than the others, the rest subequal. Sides with two upper interstices granulate. Beneath rather closely, somewhat rugosely, punctate, the basal segments transversely strigose. Legs simple; tarsi spongiose beneath except along median groove.

♀ Resembles ♂, but is much larger; elytra wider than prothorax; spines on elytra somewhat smaller, the two humeral spines almost completely conjoined to form an oblique humeral crest; convex beneath, basal segments more lightly strigose, other segments hardly rugose.

Dimensions.—♂ 12 x 5 mm.; ♀ 16 x 7; P. 4.5 x 5.5; E. 10 x 7 mm.

Hab.—Victoria, Portland (J. E. Dixon). Type in Coll. Ferguson.

Described from 2 ♂ ♂ and 11 ♀ ♀. In the type ♂ the humeral tubercles are separate, except at base, in the other ♂ and in all the females, these are almost completely conjoined.

In appearance a very ordinary *Acantholophus* the present species may be separated from most by the simple supraocular crests. Of the described species with simple crests, it differs from all except *A. gladiator* and *A. aureolus*, in having the intermediate tibiae simple and not notched at apex. From the other two, it is so utterly different that no comparison is necessary. Apart from the simple crests, the present species strongly resembles many of the Adelaidae-group.

ACANTHOLOPHUS BREVICORNIS, sub. sp. nov.

♂ Moderately large, elongate, suboblongate; very close to *Ac. dumosus*. Black; sparsely clothed with brownish squames above, sides maculate with greyish.

Rostrum gently concave above, with a shallow median groove; lateral margins subangulate in front, lowest at base; basal ridges —intercristal and oblique—moderately distinct, basal foveae rather shallow. Supraocular crests simple, very short, obtusely pointed, projecting at right angles to the upper surface of head, with no outward or backward tendency. Prothorax (4 x 5 mm.) transverse; disc with subapical and sub-basal constrictions; median tubercles relatively small, anterior pair larger, more elongate, subcristiform, other tubercles not arranged in single line, middle tubercles smaller, more outwardly placed, penultimate tubercles rather larger, somewhat backwardly projecting; lateral tubercles dentiform, broad at base, outwardly projecting, 2 large conjoined tubercles anterior to middle, one posterior to middle, also a small tubercle anterior to subapical constriction. Elytra (10 x 6 mm.) subparallel, not greatly wider than prothorax. With three rows of tubercles, the other interstices moderately coarsely granulate: first row with nine tubercles, the basal ones small, rounded, the last four spinose, becoming progressively larger; tubercles ending at edge of declivity, two or three small spicules present on declivity, the last subapical, larger, almost spines: second row with six tubercles, the basal ones small, the last three larger, outwardly projecting, and extending more posteriorly than the first row: third row with five or six from shoulder to about middle, strong outwardly-directed spines, the second somewhat larger than the rest, the others subequal or decreasing slightly in size. Beneath coarsely, rugosely punctate, the punctures longitudinally confluent. Middle tibiae with strong subapical notch.

♀ Somewhat more ovate, more convex beneath, intermediate tibiae simple.

Dimensions.— ♂ 16 x 6 mm.; ♀ 16 x 7 mm.

Hab.—Victoria, Portland (J. E. Dixon).

Described from a series of 9 specimens sent by Mr. J. E. Dixon; type in author's collection. Closely allied to *Ac. dumosus* Bohem., of which I regard it as a geographical race or subspecies. It differs from specimens of *Ac. dumosus* from King George Sound in (a) more parallel sided form, (b) shorter supraocular crests, (c) rather larger prothoracic tubercles, (d) the presence of subapical elytral spicules. These latter are smaller than in *Ac. apicalis*, from which species it also differs in the stronger elytral tubercles.

ACANTHOLOPHUS ANGUSTICOLLIS, n. sp.

♂ Elongate, ovate; size moderate. Black; moderately densely covered with brown subsquamose clothing, the larger apical and lateral elytral tubercles with lighter greyish clothing on the upper surface; abdominal segments with a few greyish setae at sides; femora with grey subapical patch on outer surface, forming an incomplete ring.

Rostrum somewhat narrower than head, rather strongly concave above, with a moderately deep, narrow median impression posteriorly; lateral margins strongly angulate in front of middle, sloping anteriorly to apex, and posteriorly to base of supra-ocular crests. Crests simple, broad antero-posteriorly, the upper edge rounded in front, feebly notched above, and produced to a small degree backwards and upwards, the apex somewhat obtusely pointed. Intercristal and oblique ridges somewhat prominent, the basal foveae rather deep. Forehead feebly concave in front. Scrobes ending far from eyes; a moderately deep groove running from in front of eye, on to side of crest, as far as notch in upper margin. Prothorax (3.5 x 4 mm.) not greatly transvere, apical margin somewhat feebly emarginate behind eyes, lobes indefinite. Subapical constriction distinct, sub-basal less so. With median and lateral groups of tubercles; intervening spaces somewhat sparsely granulate, median area with a narrow impression, deepest in middle. Tubercles of median group rather small, slightly elongate, about six in number, with three or four smaller ones about middle, more outwardly placed; anterior pair hardly cristiform, situated in front of subapical constriction, the second pair bridging over the constriction. Lateral tubercles triangularly dentiform, broad at base, flattened above, outwardly projecting; a conjoined pair in front of middle and a single one posterior to middle; also a small rounded tubercle anterior to constriction. Elytra (10 x 5.5 mm.) gently widened posteriorly; disc with three rows of tubercles, the other interstices rather conspicuously granulate. First row of tubercles about ten in number, the basal ones small rounded, the last three becoming progressively larger and spinose; second row with about ten, not quite reaching base, running backwards and outwards and reaching beyond level of first row, the basal tubercles small, becoming progressively larger, the last four or five spiniform, outwardly directed, the apical two slightly smaller than the immediately antecedent ones, and all smaller than the apical tubercles of the first row; third row with from eight to ten, largest

about humeral angle (but still smaller than the spines of the other rows), spinose, becoming smaller posteriorly and passing into mere granules. Sides with the upper three interstices distinctly granulate. Beneath subglabrous, with small, setigerous punctures; fifth segment more strongly convex than the others. Legs simple, tibiae not notched, tarsi spongiose beneath.

♀ Of more ovate form; with elytral tubercles smaller, those of the first row more numerous, and the anterior ones reduced to mere granules; apical ventral segment with a strongly raised rounded prominence, highest in middle, but occupying nearly the whole segment.

Dimensions.— ♂ 15 x 5.5 mm.; ♀ 16 x 7 mm.

Specimens of this species, taken by Mr. T. G. Sloane at Portland, Victoria, in 1887, have been long in my collection, and lately Mr. J. E. Dixon has forwarded me a long series (48) from the same locality. Though variable to a slight extent in size, there is little other difference to be detected in the series. The crest over the eye at first sight appears single, but I believe it is really composed of two conjoined tubercles; the species being therefore related to Ac. *Adelaidae* and *Ac. approximatus.*

It differs from all of this group in the relatively narrower prothorax, and in the more numerous and more closely set elytral tubercles.

Type in author's collection.

[PROC. ROY. SOC. VICTORIA 27 (N.S.), PT. II., 1914].

ART. XVIII.—*The Petrology of the Igneous Rocks near Healesville and Narbethong.*

BY NORMAN R. JUNNER, B.Sc.

(Caroline Kay Scholar in Geology, University of Melbourne, 1913).

(With Plate I.).

[Read 12th November, 1914].

1.—Introduction and Physiography.

The area described in this paper consists chiefly of an elevated series of ancient volcanic rocks, probably Devonian in age. The relief is marked, Mount Donna Buang and other peaks rising to more than 4000 feet above sea-level, whilst the bed of the Yarra at Healesville is less than 300 feet above the same datum. The Silurian sediments on the north side of the Victorian Main Divide which passes through this area, have an average elevation of between 1000 and 1200 feet, but they rise to more than 2000 feet above sea level in places. Within the area described the divide is entirely in volcanic rocks. The northern streams, of which the most important is the Acheron river, flow into the Goulburn river, whilst the southern streams all drain into the Yarra river. Waterfalls are present near the heads of most of the streams. They are principally determined by joint planes in the volcanic rocks, e.g., Stevenson's falls and the Acheron falls. The Meyer's creek falls, however, are

of a different nature, being determined by a mass of hornfels with softer unindurated sediments upstream and downstream from the hornfels.

The rocks are usually covered by dense undergrowth, especially so in the valleys, which are often impassable. The soil covering is very deep in places, and hill-slip material is often abundant, rendering geological mapping very difficult. Coarse bouldery gravels are present in the upper reaches of all the streams, and in inaccessible country of this nature they afford valuable information as to the character of the rocks within the watershed of the streams.

The dacitic rocks from this area possess many features in common with the dacites described from Mount Macedon by Professor Gregory,[1] and by Professor Skeats and Dr. Summers.[2] Rhyolites and pyroclastic rocks of (?) Devonian age are apparently absent at Macedon, although they are present at various points in the Healesville district. It was with the primary purpose of studying these less well-known rocks in the latter area, that the present research was undertaken by the writer.

2.—Previous Literature.

In 1854 Sir A. R. C. Selwyn[3] prepared a geological map of portion of the country to the east and south-east of Melbourne. The Healesville igneous rocks are roughly delineated and referred to as trap. In the accompanying report Selwyn stated that hornblendic granite passed into porphyry near Mount Monda.

In 1894 J. C. Newbery[4] described rocks from the Blacks' Spur and Fernshaw as mica porphyrite and felspar porphyrite respectively.

In 1901 E. G. Hogg[5] briefly described the microscopical characteristics of a granitic rock from the Watts' river aqueduct. He determined it to be a fine-grained granitite composed of felspar, with plagioclase in excess of orthoclase, quartz, biotite, apotite, chlorite, calcite and muscovite.

In 1902 Professor Gregory,[6] in an important contribution dealing with the Macedon igneous rocks, briefly described the allied

1 Vide infra, p. 8.

2 "The Geology and Petrology of the Macedon District." Bull. Vict. Geol. Surv., No. 24, 1912.

3 "The Geology, Paleontology and Mineralogy of the Country situated between Melbourne, Western Port Bay, Cape Schanck, etc." Rep. Geol. Surv. Vict., Nov. 1854.

4 "Descriptive Catalogue of the specimens of Rocks of Victoria, in the Industrial and Technological Museum, Melbourne," 1894.

5 "Petrology of Victorian Granites." Proc. Roy. Soc. Victoria, vol. xiii. (n.s.), 1901.

6 "The Geology of Mount Macedon." Proc. Roy. Soc. Victoria, vol. xiv. (n.s), Pt. ii., 1902.

dacitic rocks from near Healesville. He believed that the dacites were either of late Mezozoic or early Tertiary age, and he stated that "At the northern foot of the Blacks' Spur, the dacites rest on granodiorite." He described the microscopical features of a rock with flow banding from near Lindt's gateway, and concluded that it was a weathered dacite.

In 1904 F. Chapman[1] contributed a few petrological notes on the igneous rocks to the south of the area dealt with in the present paper. He determined a gneissic banded rock consisting of plagioclase (? oligoclase), augite enwrapped by brown hornblende, and hypersthene, from the Don river valley as a granulitic diorite.[2] Brief petrological notes on the granodiorite and dacite are also given.

A. E. Kitson[3] believed that the dacite series was Upper Mezozoic or Lower Cainozoic in age.

In 1908 Professor Skeats[4] summarised certain of the salient features in the petrography of the dacitic rocks near Healesville, Narbethong and Marysville. He determined the volcanic and intrusive rocks to be dacites, quartz porphyrites, quartz porphyries and granite porphyries, and he stated that "At Dandenong Hills, Narbethong, Marysville and the Strathbogie Ranges, the dacites appear to pass, by the increase of quartz and the diminution or disappearance of hypersthene, into quartz porphyries and quartz porphyrites. No sharp junctions have been noticed and it is inferred that the change is a gradual one."

In 1908 J. Easton,[5] of the Victorian Geological Survey, made a rapid survey of the boundaries of the dacite series near Healesville, Warburton, Narbethong, etc. In a brief report mention is made of the presence of normal biotite dacite, tuffs, granodiorite and trachyphonolite. He records finding the latter rock at two points near Warburton, but his determination of the rock is, without doubt, erroneous, as alkaline rocks appear to be entirely absent from this area.

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1 "Excursion to Lauching Place." Victorian Naturalist, vol. xx., No. 9, 1904.

2 In view of Professor Skeats' later work on the relations of the dacites and granitic rocks near Gembrook, it is probable that this rock is a gneissic dacite. Granodiorite and dacite come into relation near the Don river valley.

3 "Excursion to Warburton." Victorian Naturalist, vol. xxii., No. 8, 1905.

4 "The Volcanic Rocks of Victoria." Pres. Add. Sect. C, Aus. Assoc. Adv. Sci., Brisbane, 1909.

5 "Boundaries of Formations between the head of the Acheron and Yea Rivers and the Yarra." Rec. Vict. Geol. Surv., vol. ii., Pt. 4, 1908.

3.—Upper Silurian Sediments.

The basal beds of the Healesville area are a folded series of fairly shallow water marine sediments, consisting chiefly of sandstones and shales. Two fossiliferous conglomerates were found by the writer near Narbethong, one on either side of the main road from Healesville to Marysville. The western conglomerate was seen in densely overgrown country, at a point about one and a-half miles east of the above-mentioned road, and about two miles from St. Fillans. The conglomerate outcrops on a low ridge trending approximately north and south, and is well jointed. It dips east at about 70° and strikes about north and south, and contains numerous poorly preserved fossils. The pebbles are mostly rounded and sub-angular in shape, and consist almost entirely of sedimentary rocks, vein quartz and quartzite being most common, and chert and sandstone relatively uncommon.

The eastern conglomerate is visible along the now disused road from Narbethong to Marysville. It consists of exactly the same types of pebbles as occur in the western conglomerate, and contains casts of fossils, chiefly corals and crinoid stems. The direction of dip of the conglomerate was not determinate, but the sediments near by are west dipping, and presumably the conglomerate also dips in this direction. It seems likely, from the structure of this portion of the area and from the lithological similarity of the two conglomerates, that they are on the same stratigraphical horizon. The abundant pebbles of milky vein quartz are interesting, suggesting the occurrence in Victoria of quartz veins, possibly auriferous, pre-Upper Silurian in age.

The Silurian sediments at, and to the east of Melbourne, strike fairly consistently east of north. Near Healesville, however, the beds swing round and the strike changes to the west of north, and this direction is maintained as far east as Wood's Point. In Healesville township the strata trends N. 20° W. approximately. and dip about 70° to the west. In the northern portion of the area, near Narbethong and Marysville,, the average strike is between 20° and 30° west of north: No explanation is suggested for this change of strike. Clearly the effect is regional and no explanation, involving local causes, e.g., the effect of the intrusion of the igneous rocks, faulting or cross-folding can be valid.

The precise age of these beds is doubtful. Fossils are very rare, and with the exception of the poorly preserved fossils in the above-mentioned conglomerates, and certain plant remains which the

writer found in reddish-coloured sandstones and mudstones in the north of the area, no other fossils have been seen or recorded. Mr. Chapman has kindly examined these plant remains for me, and has referred them to Haliserites Dechenianus, Göppert, a fossil characteristic of his Tangilian division of the Silurian, and which is very abundant in the Tangilian beds at Wood's Point. The presence of Haliserites, the occurrence of fossiliferous conglomerates and the general lithology of these beds, all point to a close similarity with the shallow water marine or estuarine beds near Wood's Point. Tangilian marine fossiliferous strata occur at Starvation creek and McMahon's which are approximately on the continuation of the same line of strike as the beds near Narbethong and Marysville. The evidence at hand, therefore, although not conclusive, supports the belief that the sediments to the north of the volcanics near Narbethong are Tangilian, i.e., Upper Silurian, in age. In the absence of fossils from the beds near Healesville nothing definite can be said respecting their age.

Locally, near the intrusions of granodiorite, the sediments have been metamorphosed and changed to hornfels. Such alteration, however, is never very extensive.

Auriferous quartz veins traverse the sediments in places in this area, but none of them have been economically important.

4.—Petrology.

A. Granodiorite.

Granodiorite and granodiorite porphyry occur as small intrusions at several points around the periphery of the extrusive rocks. The most important localities in which these rocks outcrop are Malory's falls; the Maroondah aqueduct, north of Healesville; west of the road from Healesville to Toolangi, near Meyers' falls; Nyora and in the ranges west of Narbethong.

Malory's falls.—At Malory's falls at a height of about 2000 feet above sea level, is found a rather coarse grained, occasionally porphyritic, rock composed of quartz, felspar, biotite and garnet. Numerous pits are developed on the weathered surface of the rock due to the removal of the felspar. Biotite occurs in fine six-sided lustrous plates. Euhedral crystals of pink garnet (almandine) are fairly common. Examined microscopically, the rock is seen to be very similar to the granodiorite described from the Macedon area, by Professor Skeats and Dr. Summers.[1] It is a holocrystalline

1 Op. cit., p. 19.

rock, showing a tendency towards a porphyritic structure. Zoned plagioclase, having a nucleus of oligoclase or oligoclase-andesine, and an outer zone of albite, greatly predominates over orthoclase. Several traverses of this section showed that the ratio of plagioclase to orthoclase was approximately 3 : 1. One plagioclase phenocryst showed a highly sericitised idiomorphic core surrounded by finely zoned pellucid felspar. Orthoclase is present in simply twinned phenocrysts, including a small quantity of microperthitic albite. It is apparently identical with the type present in the neighbouring rhyolites. Titaniferous biotite occurs as deep brown idiomorphic plates. Some of the biotite has been bleached, and rutile needles have separated out in the form of sagenite webs. Pleochroic haloes due to inclusion of zircon are very noticeable in the altered mica. Inclusions of ilmenite are also common. A little muscovite is also present, but it is undoubtedly secondary. Zircon and apatite are common accessories. The garnet crystals, which appear to be homogeneous in hand specimens are seen under the microscope to be greatly fractured and to include unaltered and chloritised biotite, quartz, ilmenite and apatite. Rims of biotite often surround the garnet crystals.

Maroondah aqueduct, north of Healesville.—Granodiorite outcrops on the ridge separating Meyer's creek and Donnelly's creek. The rock is greatly decomposed near the surface, but fresh specimens are obtainable from the tips formed from the rocks taken out in the tunnelling of the above-mentioned ridge for the Maroondah aqueduct. At the western end of the tunnel contorted, steeply dipping Silurian mudstones and shales outcrop. Near the contact the sediments have been changed to hornfels. Xenoliths of metamorphosed sediments are common in the granodiorite near the contact.

In hand specimen the rock is medium and even grained, and consists of colourless quartz, felspar and abundant biotite. Pink garnets are not uncommon. Fine-grained rocks (microgranite or aplite) are occasionally present.

Section No. H100, contact of granodiorite with sedimentary Xenolith, from tunnel in Maroondah aqueduct.—The mineralogical composition of this granodiorite is very similar to that of the rock from near Malory's falls. The felspars, however, are greatly replaced by sericite and carbonates, and the brown biotite crystals are greatly chloritised, and sagenitic webs of rutile have separated out. A fair amount of granular ilmenite occurs throughout the section. Near the contact pyrrhotite makes its appearance in considerable quantities, and the place of the granular ilmenite is taken

by a prismatic variety. Laths of clear, zoned, acid plagioclase, apparently albite, are very abundant in the altered rock .

The granodiorites, from the other localities mentioned, are very similar to these rocks described above, and they do not call for further attention.

B.—Dacites.

The major portion of the area described in this paper is covered by a series of fairly normal dacites. They show considerable variation in colour and granularity, although their mineral composition is usually very uniform. Nevertheless, in the dacites from the Blacks' Spur, quartz phenocrysts are abundant and garnet is often present, and hypersthene is apparently wanting, whilst in the dacites from the summit of Mount Juliet and from the ranges at the head of the Acheron river, hypersthene is relatively abundant and macroscopic quartz phenocrysts are absent. Flow structure is rare in hand specimens of the dacites, although not infrequently visible in thin sections of the Blacks' Spur dacite. Vesicles are usually absent, and mineralisers were apparently rare, as these rocks are relatively little altered. These facts, considered in conjunction with the great thickness of these lavas, probably point to a high degree of viscosity for the extruded magma. Numerous xenoliths of fine-grained andesites resembling hornfels, and white porcelainous rocks occur in the dacites from the Blacks' Spur. Lenticular patches of more coarsely crystallised dacite, often rich in garnets, are also common in the finer grained rock from this locality. Jointing is well developed, both in the dacites and in the rhyolites. Sections along Blacks' Spur road in dacite ,and at Archer's Look-out in rhyolite, illustrate this jointing very well. The average specific gravity of the dacites is 2.71. A chemical analysis by Mr. F. Stone of a specimen of dacite from the Blacks' Spur gave the following result :—

SiO_2	65.80
Al_2O_3	16.87
Fe_2O_3	3.97
FeO	1.08
MgO	1.76
CaO	3.16
K_2O	3.45
Na_2O	2.54
H_2O	1.05
MnO	tr.
Total	99.68

The analysis is very similar to many others of Victorian dacites, and calls for no special remarks.

Specimen No. H45, from near the source of the Acheron river, resembles closely the normal dacites described from the Macedon and Dandenong areas. It consists of phenocrysts of zoned plagioclase (labradorite Ab_1 An_1), greatly corroded quartz, biotite, and occasional crystals of hypersthene, in a microcrystalline ground mass composed of quartz, plagioclase, ilmenite and (?) potash felspar. Zircorn and apatite are accessories. Occasional phenocrysts of untwinned felspar may be orthoclase. The biotite phenocrysts have been attacked by the solidifying magma, and as a result they are often fretted and contain internal cavities filled with quartz and felspar. The hypersthene is decidedly pleochroic and includes ilmenite, felspar and biotite. The absorption scheme is as follows :—

X light brown with a trace of pink.
Y brownish yellow.
Z light green.

Sections cut parallel to 010 give a biaxial figure, having a moderately large axial angle. Ilmenite occurs as idiomorphic crystals in the ground mass of the rock, and included in biotite and hypersthene.

Of particular interest is the occurrence in this section of two or three irregular shaped phenocrysts of cordierite showing the characteristic trilling.

One section in particular (vide plate I., figure 4) shows the trilling very finely. The cordierite has a refractive index greater than the balsam (μ=1.532), and is distinctly biaxial. It is not greatly altered, but contains numerous linearly arranged inclusions in certain cases.

Specimen No. H44, Blacks' Spur road, is typical of the hypersthene free dacites. It consists of phenocrysts of colourless quartz, beautifully zoned plagioclase (chiefly labradorite Ab_1 An_1), and deep brown six-sided biotite in a cryptocrystalline ground mass. Accessory and secondary minerals are garnet, tourmaline, zircon, pyrrhotite, ilmenite or magnetite (?) opal, chlorite, sericite, quartz and sillimanite. Plagioclase phenocrysts are numerous. They are usually well zoned, and show both albite and pericline twin lamellae. Maximum symmetrical extinction angles of about 27° indicate labradorite near Ab_1 An_1. Biotite is greatly chloritised, noticeably so close to the garnet crystals. It is concentrated round

the margin of the latter mineral. The garnet is seen under the microscope to consist of irregular granular aggregates, resembling the "siebstructure" of Weinschenck. Inclusions of biotite, pyrrhotite and ilmenite are present in the garnet, and it is associated with secondary quartz, zircon and tourmaline. A few lath-shaped sections are seen of a colourless mineral having moderately high refractive index, but much less than that of zircon, and exhibiting bright pinks and greens of the third order between crossed nicols. The mineral shows straight extinction, and determination of its sign by a quartz wedge proves it to be positive. It is, therefore, undoubtedly sillimanite, although its polarisation colours are rather high for this mineral. Occasional laths of a fibrous, strongly pleochroic (blue or violet to almost colourless) tourmaline, having a negative sign and normal absorption, are present in the section. Apatite and zircon are accessories.

Section No. H73, dacite, from near Donnelly's weir, consists of large fractured phenocrysts of colourless corroded quartz and fairly large plagioclase crystals, showing both Carlsbad and Albite twinning, in a fine-grained pilotaxitic groundmass composed of labradorite laths, chlorite and a little quartz. One or two vesicles, infilled with chlorite and epidote, are present in this rock. Biotite is rare, being greatly chloritised.

Assimilation.—Assimilation of either aluminous sediments or igneous rocks, has undoubtedly occurred to some extent, as is proved by the presence of cordierite, sillimanite and garnet in certain of these rocks. Numerous undigested sedimentary and igneous xenoliths are also seen in the dacites.

A. Bergeat[1] has recently described an interesting case of the melting up and assimilation of an andalusite bearing rock by an andesite, with the formation of cordierite, sillimanite, garnet, biotite, orthoclase and spinel. All these minerals, with the exception of the last named, are present in the Healesville dacites.

Origin of the garnet.—Pink garnet is relatively widespread in (?) Devonian igneous rocks in Victoria. It occurs in granite or granodiorite near Toora, Wilson's Promontory, Mount Taylor, Beechworth, Healesville and elsewhere; and in intrusive and extrusive rocks, porphyries, porphyrites, daxites, etc., from near Mansfield, Strathbogie ranges, Mount Dandenong, Healesville and Warburton. The occurrence of the garnet in these rocks under such

1 "Der cordieritaudesit von Lipari, seine Andalusit führenden einschlüsse und die genetischen veziehungen zwischen dem Andalusit, Sillimanit, Biotit, Cordierit, Orthoklas und Spinell in dem letzteren." Neues. Jaheb. Min. Geol. (Beil. Bd.) 30, pp. 575-627, 1910.

varied conditions, strongly suggests that it is a primary mineral. Although only rarely visible macroscopically in the rocks from the Healesville area, microscopic examination has revealed its presence in granodiorites, dacites, rhyolites, and tuffs. Its occurrence in these rocks (both plutonic and extrusive) certainly suggests that it was an original mineral in the magma from which these rocks were derived. Microscopical examination of these garnet-bearing rocks, however, leads one to doubt the primary origin of the garnet for the following reasons:—

1. The apparently homogeneous crystals of garnet, occurring in hand specimens of the rocks, are seen under the microscope to be aggregates of garnet grains associated with secondary quartz, pyrrhotite, chlorite after biotite, sericitised felspar, and in one case with blue tourmaline.

2. The association of garnet with pyrrhotite and chloritised biotite is characteristic. Rims of pennine occasionally surround the garnet aggregates. Pyrrhotite is often a contact metamorphic mineral, and has been noticed in the altered sediments adjoining granodiorite at the Maroondah aqueduct.

3. Garnet is apparently absent in the hypersthene bearing dacites; at least this is so in all the sections of these rocks that I have examined. Sir Thomas Holland has described certain rocks[1] in which garnet apparently replaces hypersthene, but in our case sufficient evidence is not available to determine whether such replacement has taken place.

Contact metamorphism of the volcanic rocks only becomes marked near certain of the granodiorite intrusions, and garnet is invariably absent from the contact rocks, so that it is improbable that the garnet is a contact metamorphic mineral.

Abyssal magmatic assimilation might possibly account for the presence of the garnet in the Healesville igneous rocks. Cordierite, sillimanite and garnet have been previously mentioned as forming at Lipari owing to the assimilation of an andalusite bearing rock by an andesite.

Summing up, no definite conclusion, respecting the origin of the garnet, can be arrived at, and it is left for future investigators to make a more detailed study of the question.

C.—Andesites.

Quartz free andesites are rarely met with in the Healesville area. The best example of these rocks seen by the writer occurs at a point

1 "Geology of the neighbourhood of Salem, etc." Memoirs Geol. Surv. India, vol. xxx., 1900

about two miles along the Don road, north of Launching Place. The rock is very tough and fine grained, and felspar is the only mineral visible megascopically.

A thin section of the rock examined under the microscope, consisted of phenocrysts of felspar in a fine-grained andesitic ground mass of laths and stunted prisms of plagioclase, microcrystalline quartz and magnetite dust. Chlorite, sericite and epidote (pistacite) are alternation products. Original femic minerals are lacking.

Recrystallisation has taken place in the ground mass of the original rock, and a mosaic of quartz grains has been formed. Occasional vesicles filled with chlorite and quartz are also present. The panidiomorphic plagioclase phenocrysts are well zoned, and give maximum symmetrical extinction angles of 36° from the albite lamellae, indicating plagioclase near labradorite-bytownite (Ab_2 An_3). Most of them are highly sericitised, and a little secondary epidote has been developed in the felspar in places. The ground mass laths are generally only simply twinned and are referable to labradorite.

Section No. H2, from near Wade's Look-out, is a fine-grained andesite consisting of zoned phenocrysts of rather basic labradorite, and chloritised femic mineral, in a pilotaxitic ground mass composed of plagioclase laths, biotite, chlorite and ilmenite. Quartz is absent. The section of this rock is very similar to sections of certain black andesitic xenoliths present in the dacites.

Section No. H79, biotite andesite, M.M.B.W. pipe line to Badger Creek Weir.—A thin section of the rock examined microscopically shows abundant phenocrysts of zoned plagioclase (andesine or acid labradorite), chloritised biotite and ilmenite in a yellowish coloured devitrified glassy ground mass. Quartz is almost entirely absent. Abundant granular ilmenite occurs, included in biotite, and in the ground mass of the rock some of the ilmenite is replaced by pyrites. A little epidote replaces biotite.

D. *Pyroclastics.*

Section near Wade's Look-out.—The best section of these fragmental rocks, in the area described, occurs in cuttings along the Don road from Healesville to Launching Place, above Wade's Look-out. Near the Look-out, the pyroclastics are seen resting on east-dipping silurian sediments. The former consist here of tuffs, and volcanic agglomerates containing rounded and sub-angular pebbles of rhyolite or quartz porphyry. About one-third of a mile above

Wade's Look-out, two cuttings for road metal have exposed good sections of these fragmental rocks. The following section is seen in one of these cuttings:—

A.—Dense, black, aphanitic ash resembling chert; width about 7 feet.

B.—Coarser grained tuff or ash containing occasional agglomeratic pebbles of rhyolite. It is well bedded, and dips steeply to the east; width about 5 feet.

C.—Partially unconsolidated, finely bedded tuff resembling a mudstone; width about 2½ feet.

Examined under a lens, numerous flakes of biotite and a few grains of quartz and altered felspar, and a little pyrite and muscovite are discernible in the rock. The tuff is ripple marked in places, but it is impossible to determine whether these markings are due to water action or wind. No fossils, either marine or fresh water forms, were found in these tuffs, and they appear to be entirely sub-aerial in origin.

D.—Another band of black, flinty ash.

These pyroclastic rocks all appear to dip at fairly high angles to the east, but they are well jointed and it is possible, but not probable, that jointing and bedding were confused by the author. It is possible that these tuffs and ashes were originally deposited on some fairly steep slope, but the more probable explanation of their high dip is that they have been subjected to later earth movements.

Section No. HI, black cherty ash, referred to above as A.—Under the microscope angular pieces of quartz and occasional fragments of beautifully zoned plagioclase can be recognised in a cryptocrystalline matrix. A little biotite is also present, and finely divided iron oxide is plentiful. Bedding is distinctly visible. The bedding planes, however, are not straight, but occur in the form of waves, suggesting rippling.

Section No. H3, bedded tuff, partially unconsolidated, referred to as D.—Microscopically it consists of numerous angular and oval-shaped fragments of igneous rocks largely dacitic in composition. One or two xenolites of sandstone are present in the section. The bulk of the rock, however, consists of finely-divided rock dust, and fragments of crystals, of quartz, felspar, biotite, chlorite and colourless garnet. The whole of the felspar appears to be plagioclase, and none of the orthoclase, so characteristic of the tuffs near Malory's falls, is present. Chalcedonic silica is well developed in places.

Section No. H30, xenolith in tuff, one-third of a mile above Wade's Look-out.—A leucocratic, porphyritic rock, consisting of phenocrysts of quartz, microperthitic, orthoclase, acid plagioclase and muscovite in a cryptocrystalline ground mass composed of the same minerals. Orthoclase is in excess of plagioclase. The phenocrysts of muscovite usually show included needles and sagenitic webs of rutile, and occasionally include a little epidote. They undoubtedly replace original biotite. Quartz grains are plentiful. They remain clear, although often greatly corroded. Leucoxene is fairly abundant, and one or two twinned sections of epidote are also present. The rock may be described as a quartz porphyry or rhyolite. The presence of the microperthitic orthoclase, so characteristic of the rhyolites, is interesting.

Section No. H15, xenolith in tuff, one-third of a mile above Wade's Look-out.—The rock is an altered quartz porphyry consisting of large phenocrysts of quartz, highly sericitised and kaolinised felspar, and occasional biotite crystals, in a microcrystalline ground mass. The idiomorphic outlines of the felspar and the absence of twinning suggest orthoclase. A little yellowish-brown opal occurs in places, and brown iron oxides are rather common, showing that the rock is much weathered.

Track to Malory's falls.—Tuffs are well developed near the northern foot of the Blacks' Spur, and they can be seen at numerous points along the track from near Lindt's Hermitage to Malory's falls. They are generally light coloured, white or grey, but are occasionally stained with hydrated oxides of iron. Certain of the tuffs still remain loose and cavernous, but the majority have been secondarily silicified and rendered more compact. Cubes of pyrite are common. The lapilli present in the tuffs are usually small, being rarely more than half an inch in diameter. Examined microscopically, these tuffs are seen to consist chiefly of fragments of rhyolitic rocks. Lapilli of sedimentary rocks are very rarely present. Especially characteristic, in these pyroclastics, is the microperthitic orthoclase so abundant in the rhyolite lavas.

Specimen No. H4, track to Malory's falls.—Numerous fragments of banded rhyolite are seen in hand specimens of this rock. Crystals of quartz and altered orthoclase are also visible megascopically. Examined microscopically phenocrysts of altered microperthitic orthoclase, acid plagioclase, and colourless quartz, are immediately recognised. Chloritised biotite occurs in small amount. The matrix of the rock appears to consist largely of microcrystalline silica and sericitised felspar. That secondary

silicification has taken place is evident from the silica added to some of the quartz phenocrysts. The rock is a rhyolite tuff.

Section No. H54, from near H4, is again composed almost entirely of rhyolitic debris.—Rectangular sections of muscovite, secondary after biotite, are numerous and clear, simply twinned laths of acid plagioclase are not uncommon. Microperthitic orthoclase occurs as fragments of crystals, much corroded and greatly sericitised in places. The matrix is chiefly finely granular silica, chalcedony, and sericitised felspar. Certain colourless isotropic cubes, of a mineral having a refractive index much less than that of the ground mass, are undoubtedly fluorite.

Section No. H9, track to Malory's falls, is made up of lapilli of andesitic and rhyolitic rocks and fragments of chlorite, secondary after biotite, quartz, plagiolcase, biotite and highly sericitised orthoclase in a matrix composed chiefly of quartz and sericitised felspar. Abundant leucoxene and zircon occur scattered through the section. Microperthitic orthoclase is almost entirely absent. One or two fragments of garnet are also present.

Section No. H39, immediately west of the Blacks' Spur road, on the track to Malory's falls.—Fluorite cubes are again present in this section. The rock is a normal rhyolite tuff.

M.M.B.W. pipe line to Badger Creek Weir, S.S.W. of Mount Riddell.—Ashes, tuffs with fine lapilli, and coarse agglomerates are all present in the rocks from this locality. The agglomerate pebbles are usually small, being rarely more than three inches in diameter, and are mostly sub-angular in shape. They consist almost entirely of a yellowish-green, aphanitic, pyritised rock resembling in hand specimen the Diamond creek dyke rock. No signs of bedding are visible in any of the tuffs. They are frequently honeycombed, and secondary carbonates, sericite and pyrites have been developed in them.

Specimen No. H88, pebble in agglomerate, S.S.W. of Mount Riddell, is a leucocratic, aphanitic rock showing minute grains of quartz, felspar and a little pyrite in hand specimen. Microscopically, it consists of phenocrysts of altered felspar, quartz and a little chloritised femic mineral, in a ground mass of quartz, felspar laths and occasional ilmenite. Carbonates, sericite, chlorite, rutile and leucoxene are secondary minerals. Veinlets of quartz and carbonates traverse the rock. The felspar phenocrysts are predominantly orthoclase; highly sericitised in general and often carbonated. The plagioclase phencrysts are of albite or albite-oligoclase, and are not zoned. The grains of quartz are pellucid as

usual, but are often greatly fractured and corroded. The rock is a metasomatically altered rhyolite of quartz porphyry.

Section No. H91, xenolith in tuffs, S.S.W. of Mount Riddell, is a slightly metamorphosed granodiorite. Biotite is greatly replaced by chlorite (pennine) and rutile has separated out as sagenitic webs. Abundant pyrrhotite occurs throughout the section, replacing much of the original ilmenite. The felspars are greatly altered, but plagioclase appears to be in excess of orthoclase.

Section No. H94, andesite tuff, from same locality as preceding specimens. Under the microscope the rock is seen to consist largely of fragments of andesite showing fine pilotaxitic texture. The original biotite crystals have been replaced by strongly pleochroic chlorite (pennine) and epidote (pistacite), and leucoxene has separated out. Quartz phenocrysts are rare, but the bulk of the matrix of the rock appears to be silica, some of which is chalcedonic. Occasional crystals of colourless isotropic garnet are seen in the section. The felspar phenocrysts and ground mass laths appear to be almost entirely plagioclase, often well zoned.

Track to Maroondah weir.—Doubtful fragmental rocks occur near Maroondah weir. Specimen No. J1, metasomatically altered rhyolite tuff or rhyolite, one mile south-west of Maroondah weir, is typical of these rocks. Hand specimens are brecciated, consisting of fragments of a light-coloured rock in a darker coloured matrix. Thin sections of the rock examined microscopically show that silicification, carbonation and sericitisation have greatly affected the original rock. The primary minerals include simply twinned orthoclase, plagioclase, corroded and fractured quartz, garnet, zircon, sphene, apatite and a (?) femic mineral which has been entirely replaced. Muscovite, carbonates (? dolomite), chalcedony, quartz pyrites, (?) opal and brown iron oxides are secondary. Most of the plagioclase has a refractive index less than that of quartz, and appears to be albite, but certain zoned sections give symmetrical extinction angles of 22° from the albite lamellae, indicating andesine. Massive cleaved carbonates and flakes of sericite replace much of the felspar. A little secondary, radially arranged, albite has been developed in one place in the section. Yellow-brown aggregates and double wedge-shaped sections of sphene, showing bright pinks and greens of the third order under crossed nicols, are not uncommon. The garnet is rarely idiomorphic, occurring more often in corroded and irregular-shaped grains. Microspherulitic chalcedony, showing a black cross under crossed nicols, occurs throughout the section. Minute veins of quartz traverse the rock.

Section No. H101, one mile S.W. of Maroóndah Weir.—Sharp rhombs of dolomite occur in places, associated with secondary quartz and iron oxides. Microscopic veinlets of banded silica and carbonates intersect the rock.

Fragmental rocks, tuffs and flinty breccias whose fragmental character is only revealed on weathering, also occur to the south and south-west of Mount St. Leonard.

E.—Rhyolites.

With the single exception of Professor Skeats' reference to quartz porphyries and porphyrites occurring near Narbethong and Marysville, there is no mention, in the literature of the area, of extrusive rocks more acid than the dacites. However, at Archer's Look-out, St. Ronan's Well, near Lindt's Hermitage, the Acheron river above St. Fillan's, and at several other points north of the main divide, normal rhyolites outcrop. These rocks are characterised in hand specimens by abundant quartz phenocrysts, and by the paucity of femic minerals. Rhomb-shaped sections of glassy or pearly orthoclase can be recognised in nearly all hand specimens of these rocks. Fluxion banding is often well developed. A chemical analysis of the rhyolite from Archer's Look-out was made by the writer in the geo-chemical laboratory of the Royal College of Science, London, and gave the following result:—

	I.	II.
SiO_2	74.39	78.64
Al_2O_3	14.28	9.85
Fe_2O_3	0.52	0.54
FeO	1.09	2.00
MgO	0.27	0.10
CaO	0.24	0.80
K_2O	5.33	5.16
Na_2O	2.78	2.03
H_2O+	0.22	0.40
H_2O-	0.56	0.14
CO_2	abs.	—
TiO_2	0.29	0.67
P_2O_5	tr.	tr.
BaO	n. det.	—
MaO	n. det.	—
Total	99.97	100.33
Sp. Gr.	2.49	

I. Rhyolite, Archer's Lookout. Analyst, N. R. Junner.
II. Rhyolite, Mount Wellington. Analyst, E. O. Thiele.

Using H. C. Richards' analysis of the biotite from the dacite near Mount Dandenong, with slight adjustment of the relative proportions of FeO and MgO to fit the percentages of these constituents in the rock, we can determine approximately the mineral composition of the rock. Thus :—

Quartz	37.20
Orthoclase	29.47
Albite ($Ab_{88}An_4$)	24.69
Biotite	3.65
Magnetite	0.70
Excess Al_2O_3	3.47
Excess H_2O	0.67
Total	99.85

Much of the felspar is changed to kaolin, so that this mineral will account for a certain amount of the surplus Al_2O_3 and H_2O. The percentages of iron oxides, magnesia, and lime are all low, and there is a corresponding small percentage of lime-bearing felspar and femic minerals present in the rock. Microscopical examination shows that the felspar phenocrysts are orthoclase, containing microperthitic inclusions of soda felspar, accounting for the moderately high percentage of soda in the rock.

Microscopical relations.—A section of the rock analysed showed phenocrysts of quartz and kaolinised orthoclase in a microcrystalline ground mass consisting of quartz, orthoclase and biotite. Zircon and apatite are accessories. Secondary minerals include chlorite, kaolin, hematite, sericite and a little biotite, tourmaline and brown opal. A micrometric analysis of the rock showed that the ratio of ground mass to phenocrysts was approximately 1.1 :1. The orthoclase phenocrysts are often idiomorphic and are sometimes rounded by corrosion of the ground mass. They occasionally show the characteristic cross fracture of sanidine. Carlsbad twinning is not uncommon. The phenocrysts of quartz are occasionally hexagonal in section, but are more often rounded and embayed by the ground mass. Numerous cracks and abundant glass inclusions are present in the quartz. Biotite occurs sparingly as phenocrysts, but is abundant in aggregates of minute flakes, in the ground mass of the rock.

Section No. H50, Archer's Look-out, shows phenocrysts of quartz, sanidine, and altered biotite in a microcrystalline ground mass consisting of the same minerals, together with tourmaline,

sericite, and a very little ilmenite. The texture is porphyritic. Flow banding is very well developed, yet the ground mass is thoroughly crystalline.

A beautiful blue tourmaline occurs scattered through the section in mossy aggregates. These aggregates examined under the high-power resolve into groups of acicular crystals and hexagonal cross sections of these needles. Pleochroism is very marked, varying from ultramarine to yellowish or greenish-brown. An anomalous feature of this mineral is that its strongest absorption is in the same direction as in biotite, which also occurs in the same section. It seems probable that the tourmaline replaces biotite and that it has retained the original form of the mica.

Minute flakes and prismatic sections of biotite occur throughout the section. These are probably secondary in origin. The original biotite differs from them in having much larger sections, and in its corrosion by the magma and separation of oxides of iron and titanium. A brown, isotropic mineral, having a refractive index less than the balsam and occurring in small amount in the section, is opal. It is fringed with secondary biotite in places.

Section No. H57, Acheron River, above St. Fillans.—This rock consists of phenocrysts of deeply embayed colourless quartz, turbid microperthitic orthoclase, and a little biotite and albite, in a cryptocrystalline ground mass which was originally glassy and microspherulitic. Minute spherulites, preserved in quartz, are not uncommon in the ground mass of the rock. Chlorite and brown iron oxide replace the original femic mineral which was probably biotite. Prisms of tourmaline, showing normal absorption, are associated with chlorite or serpentine in places.

Section No. H49, Acheron River, above St. Fillans.—Aggregates of blue tourmaline showing anomalous absorption are present in this section. The tourmaline occurs associated with muscovite and replaces biotite, whose form it retains. Plagioclase phenocrysts are absent, but a little albite occurs in the ground mass of the rock.

Section No. H67, banded rhyolite from near Malory's falls.—Chalcedonic silica, with nuclei of slightly yellow coloured, apparently isotropic material, having a refractive index much greater than the chalcedony, occurs in places in this section.

Certain obscure flinty rocks occurring near Mount St. Leonard may be best described under the heading of rhyolites, although the writer is quite prepared to admit the possibility of their being silicified tuffs.

Section No. H77, from Meyer's creek road, south-west of Mount St. Leonard, is typical of these rocks. It consists of phenocrysts of quartz and occasional highly sericitised crystals of orthoclase and plagioclase, in a microcrystalline ground mass of quartz, biotite and altered felspar. The structure of the rock is homogeneous. Radial aggregates of secondary biotite have been developed in association with mosaics of secondary quartz and a little pellucid felspar.

Section No. H72, from same locality as the preceding specimen.—Microscopically it consists of occasional phenocrysts of pellucid very rounded quartz, and a few panidiomorphic phenocrysts of highly altered felspar in a micromosaic of quartz, felspar, sericite, iron oxides, biotite and pyrite. One rather rounded and broken crystal of slightly pink garnet occurs associated with a little biotite and muscovite. Irregular shaped grains of pyrite are seen replacing felspar in places in this section.

F.—Metasomatically altered rocks.

The dacites in the Healesville area are remarkably fresh, and except for the occasional presence of chlorite, epidote, sericite and very rarely tourmaline, they remain unaltered. It has been previously suggested that the dacitic lavas were very viscous and poor in mineralisers; hence, perhaps, the minor alteration of these rocks. The basal volcanic rocks,—the rhyolites, and tuffs,—however, have been greatly altered in places. These metasomatically altered rocks are best seen along the aqueduct from the Badger river, south-west of Mount Riddell. Here, a greenish-coloured, compact rock, veined with carbonates and quartz are locally greatly pyritised, outcrops. Examined under a lens, some of the limonitised pyrites appears to contain native gold. In the absence of assays of the pyrites, however, one cannot assert definitely that gold is present in these rocks. The fact that gold has been won from the Badger creek, near by here, is perhaps significant. According to Professor Skeats, gold has been obtained from creeks passing only over dacites near Marysville and Gembrook, but its mode of occurrence is not known.

Specimen No. H80, from south-west of Mount Riddell, is typical of these propylitised rocks. Hand specimens are compact and aphanitic, and of a greenish-grey colour. The specific gravity of the rock is 2.80. Examined microscopically it is seen that the original rock has been greatly replaced by carbonates, chlorite,

sericite and pyrites, much of which has been oxidised to limonite and hematite. One large, simply twinned, phenocryst of orthoclase remains. It is partly replaced by sericite and granular chlorite and a little carbonate.

Other idiomorphic felspar crystals are seen to be entirely replaced by carbonates, chlorite (pennine), and sericite. The quartz phenocrysts still remain clear, although greatly corroded and partially sericitised in places. Small lenticular vesicles, infilled with carbonates and quartz, are occasionally present. Veinlets of carbonates, chlorite and a little quartz traverse the rock. Carbonates are abundant throughout the ground mass of the rock, especially replacing felspar laths. The alteration of the tuffs and agglomerates, that occur near by here, has been previously described.

Near the Echo tunnel, in the Maroondah aqueduct, and also near the Maroondah weir, carbonation, sericitisation and pyritisation have taken place in the basal volcanic rocks underlying the normal dacites.

Secondary tourmaline and biotite have been mentioned as forming in the rhyolites near Archer's Look-out, and in the tuffs near here fluorite is occasionally present.

This alteration has been ascribed by the writer to the action of vapours released from the neighbouring granodiorite.

5.—Field Relations and Origin of the Igneous Rock.

A.—Relationship of the granodiorite to the sedimentary and volcanic rocks.

Wherever seen the granodiorite is intrusive into the Silurian sediments, and has altered the latter for some distance from the junction. Xenoliths of hornfels are also common in the granodiorite near the contact.

The relationship of the plutonic rock to the igneous rocks, however, is not so evident. Selwyn stated that hornblende granite passed into porphyry near Mount Monda, and Ferguson also believed that there was a gradual passage between the plutonic and volcanic rocks near Gembrook.[1] However, Professor Skeats has shown clearly that near Gembrook and Macedon, the granodiorite is intrusive into the normal dacite, and that the latter rock has been rendered gneissic in places near the contact. Whenever the two rocks come into relation in the Healesville area marked con-

1 "Notes on certain Geological Features of the Parishes of Gembrook North and Nangana." Prog. Rept. Vict. Geol. Surv., No. 8, 1894.

tact alteration of the dacite is usually absent. However, near Nyora the dacite contiguous with the granodiorite has been rendered gneissic, and in the ranges to the west of Narbethong a gneissic dacite was seen by the writer near the contact with granodiorite. Clearly, in the Healesville district as elsewhere in Victoria, the intrusion of the granitic rock took place after the extrusion of the dacite.

Near Malory's falls rhyolite is apparently superposed on granodiorite. No alteration of the rhyolite near the contact is visible in hand specimens. However, thin sections of the rhyolite show the development of secondary biotite and blue tourmaline, and the writer attributes this alteration to the action of vapours given off from the cooling plutonic rock. Fluorite has also been formed in the tuffs near Malory's falls. More certain evidence of the subsequent intrusion of the granodiorite, e.g., apophyses or dykes from it passing into the rhyolites was not obtainable. In the sequel, it will be shown that the dacite is younger than the rhyolite, adding further support to the sequence suggested above.

Secondary biotite has also been formed in the obscure flinty rocks, probably rhyolites, from near Mount St. Leonard. Granodiorite outcrops on the east bank of Meyer's creek, close by here, and it is probable that the alteration in the rhyolite was brought about owing to the intrusion of the plutonic rock.

B.—Relationships of the volcanic rocks to one another.

That the pyroclastic rocks were associated with the rhyolitic outburst, and were previous to the dacitic activity is certain from the following facts :—

1. Everywhere in the area, the tuffs occur marginal to the dacites, and clearly underlie them at certain points.

2. Near Wade's Look-out and Badger weir, quartz porphyry and rhyolite pebbles and lapilli, from the agglomerates and tuffs, are often seen to have been caught up in the lowest layers of the dacite.

3. The tuffs throughout the area are composed of rhyolitic debris, and andesitic or dacitic ejectmenta are generally absent from them.

A traverse up the Acheron river from St. Fillans shows that the dacites overlie the rhyolites in this area. The latter rocks, which, near their contact with the Silurian sediments contain little biotite, become richer in this mineral close to the dacites,

yet, they appear to be sharply defined from one another. The superposition of the dacites on the rhyolites near the Acheron River, and the inclusion of fragments of the latter rock in the former at certain places, are sufficient to prove the subsequent extrusion of the dacites. The position of the quartz free andesites is not certain. They occur marginal to the dacites near Launching Place, suggesting that the latter rocks overlie them. Numerous xenoliths of andesite occurring in the Blacks' Spur dacite, may also indicate a subsequent origin for the dacite. However, in the absence of more certain evidence it is better to leave the question of the age of the andesites unanswered. The evidence brought forward is sufficient to establish the following sequence, from older to newer—

Rhyolites and rhyolitic tuffs,
Andesite,
Dacites,
Granodiorite.

The sequence, viewed broadly, shows the order of extrusion to be one of increasing basicity.

C.—*Origin of the rocks.*

Without much doubt all these rocks have been derived by differentiation from a common magma. Whether the differentiation is of a serial or complementary type, cannot however be determined with certainty in the absence of chemical analyses of all these rocks. The question of differentiation has been attacked exhaustively in the Macedon area by Professor Skeats and Dr. Summers, and at Dandenong, by Mr. Morris, and their conclusions leave no room for doubting that the granodiorites and dacites in these areas are consanguineous. If any further evidence is needed in the Healesville area to establish the comagmatic origin of the rocks, the striking similarity in their mineralogical composition and their intimate association in the field may be put forward in support of this view. Especially significant is the occurrence of zone plagioclase and microperthitic orthoclase in the granodiorite, and exactly the same types of felspar in the dacites and rhyolites. Garnet is also present in all of these rocks.

6.—Conclusions.

1. Folded Upper Silurian shallow water marine sediments form the basal beds of the Healesville area. Fossils are rare. Haliserites Dechenianus, Göppert, was found in the north of the

area, determining the age of the beds as probably Tangilian. Poorly preserved corals and crinoids, occur in conglomerates from near Narbethong.

2. The vulcanicity in this area commenced in ? Devonian times, after the folding and uplift of the sediments. Extrusion of rhyolites, accompanied by minor explosive outbursts, inaugurated the cycle of volcanic activity. The expiring rhyolitic vulcanicity was marked by the passage of hydrothermal solutions, containing alkaline carbonates and sulphides, in solution, through the previously consolidated igneous rocks.

3. A great thickness of dacitic rocks, including quartz free andesites, biotite dacites, and hypersthene biotite dacites succeeded the rhyolites and pyroclastic rocks, and covered up most of them. The latter rocks are now only visible around the periphery of the dacites, where denudation has been greatest. There is good reason to believe that the dacitic magma was very viscous. Steam cavities are almost entirely absent, and mineralisers which would have decreased the viscosity were apparently scarce.

Later still, granodiorite was intruded at several points. Subsequent denudation, which has been greatest around the margins of this volcanic pile, has exposed certain of these intrusions.

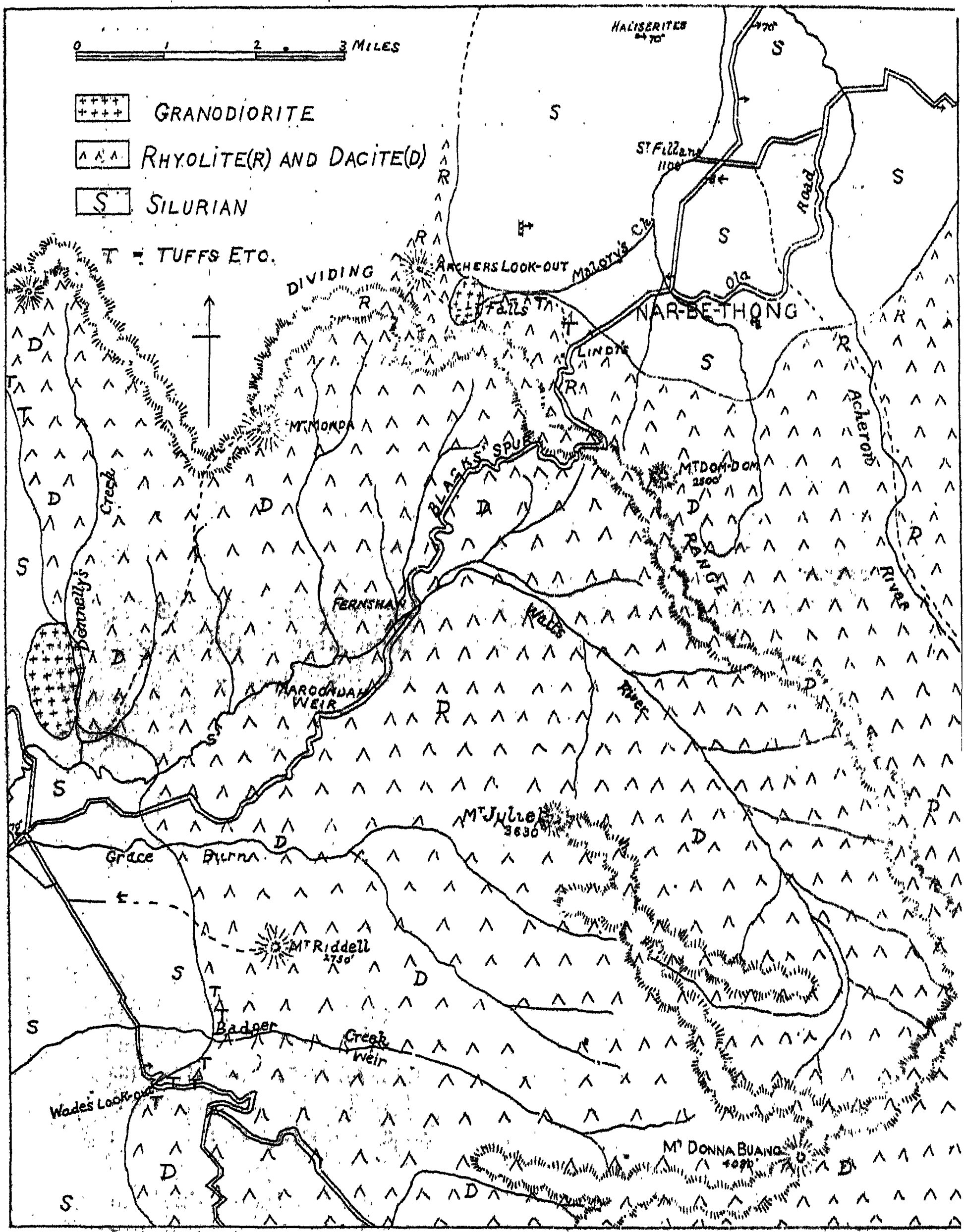
The volcanic activity appears to have been entirely sub-aerial. There is no evidence present anywhere in the area of lacustrine or marine sediments associated with the igneous rocks.

4. It is very probable that all the igneous rocks described are congeneric. The more complete evidence available from other areas in Victoria, e.g., Macedon and Dandenong, where somewhat similar rocks are present, supports this belief. The sequence of eruption was apparently one of increasing basicity.

5. Magmatic fusion and assimilation of aluminous rocks by certain of the dacites has taken place, and as a result cordierite, sillimanite and, possibly, garnet, have been formed.

6. The origin of the garnet remains unsolved, but it seems very likely that it is a primary mineral in the rocks. Its extensive occurrence, in granites, porphyries and dacites elsewhere in Victoria, supports this contention.

In conclusion, the writer desires to express his indebtedness to Professor Watts, for many facilities granted him in the carrying out of this research at the Royal College of Science, London; and to Professor Skeats, for advice and suggestions.



Geological and locality sketch map of the Healesville and Narbethong area. The junctions of the rhyolites and dacites are not shown owing to the mapping of their boundaries not being completed.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1.—Microphotograph of a fractured garnet crystal occurring in dacite from the Blacks' Spur. Inclusions of colourless quartz and black pyrrhotite are visible. Ordinary light, × 14.

Fig. 2.—Microphotograph of cherty ash, from a cutting in the road, one-third of a mile above Wade's Look-out. Rude bedding planes are visible in this section. Ordinary light × 12.

Fig. 3.—Microphotograph of a finely corroded, originally idiomorphic, quartz phenocryst, occurring in rhyolite, from the Acheron River above St. Fillans. Ordinary light × 31.

Fig. 4.—Microphotograph of a cordierite trilling in dacite, from near the head of the Acheron River. Crossed Nicols, × 50.

Fig. 5.—Microphotograph of andesite, from the Don road, 2 miles north of Launching Place. Ordinary light × 25.

Fig. 6.—Microphotograph of porphyritic rhyolite, from Archer's Look-out, Narbethong. Flow structure around an idiomorphic phenocryst of quartz is well seen. Ordinary light × 25.

[PROC. ROY. SOC. VICTORIA, 27 (N.S)., PART II., 1914].

ART. XIX.—*On the Occurrence of Igneous Pebbles in a Conglomerate of Upper Silurian Age from near Walhalla.*

BY NORMAN R. JUNNER, B.Sc.

(With Plate II.)

[Read 12th November, 1914].

Introduction.

During a short visit made to Walhalla in June, 1913, with the primary purpose of studying the relations between the auriferous quartz reefs and the intrusive rocks there, my attention was drawn, through the medium of a description in Mr. Herman's report on the Walhalla Gold-field,[1] to an interesting conglomerate, containing pebbles of igneous rocks, which was interbedded with limestones, shales and grits of Yeringian age. It was at once evident, from a cursory examination of the conglomerate, that Mr. V. R. Stirling's idea[2], of an immense fault and associated fault breccia was untenable; and further that the igneous pebbles had no genetic connection with the so-called diorite dykes which are so characteristic a feature at Walhalla.

Many of the pebbles showed very little in hand specimens, and it was only after sectioning them that their interesting nature was revealed. Unfortunately, the time at my disposal was rather limited, and my examination of the conglomerate and collection of pebbles were not as detailed and thorough as they might have been.

Previous Literature.

In 1878, Mr. R. A. F. Murray[3] noted the presence of grits associated with the limestone near the Thomson river, but did not mention the occurrence of igneous detritus in the grits.

In 1899 Mr. V. R. Stirling[4] described a belt of breccia occurring near the Thomson river copper mine. According to him

1 "Report on the Walhalla Gold-Field." Spec. Rept. Dept. Mines, Vict., 1901.

2 "Notes on alleged Copper Occurrences at Cooper's Creek." Monthly Prog. Rep. Vict. Geol. Surv., No. 2, 1899.

3 Prog. Rep. Vict. Geol. Surv., No. 5, p. 47.

4 "Notes on alleged Copper Occurrences at Cooper's Creek." Monthly Prog. Rep. Vict. Surv. No. 2, 1899.

it consisted of sub-angular and rounded fragments of quartzite, decomposed diorite, limestone, etc., in a dark-coloured siliceous matrix in part calcareous, and was associated with a decomposed dyke and a belt of limestone. He concluded from the following evidence :—

(a) The direct association of the breccia with the decomposed dyke;

(b) The appearance of presumably the same belt of breccia and dyke, first, on one side of the limestone, and then on the other;

(c) The occurrence of included fragments of limestone in the breccia;

that the breccia was probably of volcanic origin, occupying an immense strike fault in the silurian rocks.

In 1901, Mr. H. Herman[1] described in some detail the relations between the beds near the Thomson river. He states that "A gradual transition in texture can be traced from the coarse fossiliferous conglomerate . . . through fossiliferous shales with crinoid stems, to highly calcareous encrinital shales, and finally to encrinital limestone or marble." He regarded the conglomerate as a normal shore line deposit, and explained the presence of limestone pebbles in it, as either due to contemporaneous erosion or thought possibly that they may have been derived from a pre-existing formation. Mr. F. Chapman[2], in 1907, described the fossils occurring in the limestone near the Thomson River copper mine. He mentioned the occurrence of flakes of biotite and chlorite, and contorted bands of tuffaceous andesitic ejectmenta, in sections of the limestone, and suggested that volcanic activity took place contemporaneously with the deposition of the limestone.

Field Relations near the Thomson River, Walhalla.

The Silurian sediments near Walhalla[3] consist lithologically of sandstones, shales and slates, for the major part, but lenticular bands of limestone associated with gritty and conglomeratic beds are not unusual. The structure is geosynclinal with thin bedded, highly cleaved, shales and slates in the centre of the geosyncline, and more coarsely grained sandstones and gritty beds towards the margins.

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1 Op. cit., p. 12.

2 "The fossiliferous limestones and conglomerates of the Thomson and Tyers rivers and Marble creek, Gippsland." Records Vict. Geol. Surv., vol. ii., pt. 1.

3 For geological map and sections of the locality dealt with, vide Herman, op. cit.

Near the Thomson River copper mine the beds dip easterly, at angles between 50° and 70°, and strike N. 15° E. to N. 20° E.; and the general stratigraphical succession, from the west to east, starting from a point about half a mile west of the Thomson River, is as follows:—

(1) Normal shallow water marine sediments chiefly shales and sandstones.

(2) A band of conglomerate and gritty beds, well seen in sections on the track from the Copper Mine township to the Jubilee Mine, and also in cuttings near the limestone quarries in Cooper's Creek.

(3) Overlying these conglomerates and fossiliferous grits in the Cooper's Creek section, occurs a lenticular mass of dense black limestone, highly fossiliferous, and traversed by veins of calcite. The limestone matrix weathers more rapidly than the fossils, and as a result the latter are often seen in fine relief on the weathered surface of the rock. The forms present are chiefly corals, crinoids, brachiopods, and polyzoa, and they are very similar to the fossils occurring in the Yeringian limestone at Lilydale. Bedding is not very evident in the massive limestone, but occasional shale bands serve to define it. This band of limestone is not present in the section along the road from the Copper Mine township to the Jubilee Mine. The corresponding strata, in this section, overlying the conglomerate, consist of grits and calcareous shaly beds, and one or two narrow bands of black, honeycombed chert, which undoubtedly replaces fossiliferous gritty beds.

4. Another outcrop of similar black limestone occurs not far east of the above mentioned beds. At the time of my visit to the locality, it was being quarried immediately to the north of Cooper's creek, near its junction with the Thomson river. This patch of limestone does not extend far to the south, for sections on the same line of strike at the Thompson River show that the massive limestone is absent, and that its place is taken by calcareous, fossiliferous grits containing pebbles of quartzite, and limestone nodules composed in some cases almost entirely of corals. No igneous pebbles were seen by the writer in this conglomerate.

Pebbles of igneous rocks are very numerous in the first mentioned conglomerate. The majority of these pebbles are well-rounded, and they are generally small, being rarely more than three inches in diameter, although Mr. Herman mentions that pebbles up to 6 inches or 8 inches in diameter, are occasionally present. They are partly set in a fine brownish coloured, granular

matrix, resembling decomposed igneous material. The pebbles appear to be chiefly volcanic, but occasionally coarsely crystalline rocks, plutonic and metamorphic in character, are seen. According to Mr. Herman[1] diorite pebbles are predominant; but in my limited examination I came across no such pebbles. Microscopical examination of thin sections of these rocks shows that many of them are closely related to one another; and in the specimens collected by the author, all stages are represented between hornblende diabase, and the spherulitic facies of the same rock, or variolite. No acid igneous rocks, either plutonic or volcanic, were found.

Section near the steel bridge over the Thomson river, about two miles north of its junction with Stringer's Creek:—The river, which has followed the strike of the sediments for some considerable distance below here, at this point, cuts across the strike, and good sections are available, especially so on the east bank of the river where cuttings made by the Long Tunnel Company for a tram track, have uncovered the sediments.

Fossiliferous grits and calcareous beds with occasional patches of limestone occur at intermediate points between Cooper's Creek and the steel bridge, and are again present further north of this point. These outcrops are all in east dipping beds, and are on the same line of strike as the Copper Mine series of limestones and conglomerates, and are undoubtedly the northern continuation of the same beds.

The section, near the steel bridge, shows that the beds consist of hard, indurated black and grey, fine grained sandstones and shales, interbedded with well cleaved slates, and coarse grit bands and conglomerate; all dipping east at 50° to 70°. The beds throughout the section are calcareous, and locally contain highly fossiliferous lenticles and nodules of limestone. A fairly gradual passage can be traced from gritty sandstones into coarse fossiliferous grit and conglomerate. The grits are often honeycombed owing to the removal of the fossils. In the more calcareous beds the fossils are preserved in their original calcareous matrix. Corals (Favosites chiefly) and crinoids appear to be the most common fossils in these beds.

The band of conglomerate is well seen on the north side of a small creek entering the Thomson River from the east. Pebbles of quartzite are most common in this conglomerate, and igneous

1 Op. cit., p. 12.

pebbles are not numerous. Others of vein quartz, sandstone, slate, limestone and rarely chert were found by the writer. These pebbles are usually small and rounded. Some of them are well jointed by planes perpendicular to their longest axes, and these joint planes are occasionally covered with a film of pyrites. Undoubtedly this conglomerate, like the one near Cooper's Creek, is a normal marine shore line deposit.

The author saw no evidence anywhere of the immense fault referred to by Mr. Stirling, and he feels convinced that no such fault exists. No slickensides or gouges were seen; and the shape of the pebbles does not support the view that they have originated by faulting. No great disturbance of the strata has taken place, and there is no evidence of any displacement of the beds. The petrological characters of these pebbles disprove of the idea that they were formed by the brecciation of the associated dyke, referred to by Mr. Stirling, and forcibly suggest that they were derived from pre Upper Silurian igneous rocks. The only series of volcanic rocks in Victoria, known to be pre Silurian in age, are the Heathcotian, and hornblende diabase and associated pyroclastic rocks are characteristic of this series. The pebbles of gneiss in the conglomerate must, undoubtedly, have come from the pre Cambrian metamorphics of eastern Victoria, and the large felspar crystals, referred to by Mr. Stirling[1], may have come from the same source.

Further, Mr. Stirling's strong point of the occurrence of the breccia first, on the east side of the limestone near the Copper Mine township, and on the west side of it further south, can be explained away when it is recognised that the limestone bands are lenticular, and are not persistent in strike, and that there may be two or more lenticular patches of limestone not quite on the same line of strike.

Moreover, the evidence at hand does not support Mr. Chapman's belief in contemporaneous andesitic vulcanicity. It seems to me more probable, as Professor Skeats[2] has suggested, that the volcanic debris included in the limestones, is detrital. The associated conglomerates and grits contain abundant, undoubtedly detrital, igneous pebbles, and it is quite natural to expect that some of this material should be deposited with the limestones. The field relations do not lend any support to Mr. Chapman's sugges-

1 Op. cit.

2 "The Volcanic Rock of Victoria." Pres. Add., Sect. C., Aus. Assoc. Adv. Sci., 1909.

tion, and therefore, inferences drawn from the results of a microscopic examination of thin sections of these rocks, must be accepted with caution. Associated interbedded lavas or tuffs are absent, and the igneous fragments present in the limestone can be most easily explained on the assumption that they were derived from the same source as the detrital igneous pebbles. No indubitable Silurian igneous rocks have been recognised in Victoria, and more definite evidence than that brought forward by Mr. Chapman, is needed to establish Silurian vulcanicity. The present writer agrees with Mr. Herman that the conglomerates and grits are normal shore line deposits, and that the included igneous pebbles are derived from pre-existing formations.

Petrology.

Hornblende gneiss.

Specimen W1, pebble in conglomerate, section on road to Jubilee Mine.

The hand specimen of the rock is coarse grained. Felspar and hornblende can be recognised megascopically.

Examined microscopically, the rock shows very well the effects of mechanical dynamic metamorphism. Strain polarisation has been developed in the quartz grains, and they are considerably mylonitised. The horneblende is almost entirely light green actinolite. The prisms and plates of this mineral are very rarely idiomorphic, and are often twisted and bent in all directions. The elongation of the hornblende crystals is parallel to the direction of foliation of the rock. They are occasionally twinned according to the usual law; with twin and composition plane 100. One idiomorphic basal section showed an excentric emergence of an optic axis. Determination of the axial plane showed that it bisected the obtuse angle between the cleavages, and that it was parallel to the clinopinacoid, as is usual for hornblende. It is moderately pleochroic, giving the following colour scheme:—

X light yellow green.
Y light green.
Z bright green, and $Z > Y > X$ as usual.

The maximum extinction angle from the prismatic cleavage is 15°. The felspar is greatly kaolinised, and has suffered a considerable amount of mechanical deformation. Plagioclase appears to be in excess of orthoclase. The refractive index of the plagioclase is

at times greater, and at other times less than that of the quartz, and hence it appears to be oligoclase or oligoclase-andesine. Sphene is not uncommon as irregular shaped dusty masses. Rarely it is present as double wedge shaped crystals. A little chlorite occurs replacing the hornblende; quartz is not abundant. Apparently the original rock was an intermediate plutonic rock.

Hornblende diabase (Epidiorite).

Section W2. Pebble in conglomerate near the Thomson River copper mine, is a holocrystalline, fairly even grained rock with pilotaxitic fabric. There is a tendency towards an ophitic texture in places, but it is never very pronounced. Plagioclase and actinolite constitute almost the whole rock, but there is also a little quartz, ilmenite, chlorite and zircon present. The actinolite occurs usually in anhedral grains and masses. It is moderately pleochroic, varying in colour from light green to almost colourless. It is ophitically penetrated by the felspar in places. Most of the felspar laths are either simply twinned, or untwinned. Owing to their extensive sericitisation, it is frequently impossible to determine their original characters. Extinction angles as high as 35^{o} from the twin planes were measured on certain felspars, indicating a rather basic labradorite. Interesting outgrowths have taken place around the original felspar laths. Their idiomorphic outlines are generally visible as greatly altered cores, surrounded by a clear outer zone of albite showing ragged boundaries.

One interesting case, of additional material being added to a former idiomorphic crystal of felspar at two different periods, was visible in this section. By the first addition the idiomorphic crystal became rectangular in outline. Both the original crystal and the added material were now completely sericitised, and a second marginal addition of pellucid felspar took place. The twinning of the original felspar extends through the clear exterior zone, showing that the addition has been in crystallographic continuity with the primary felspar. The method of formation of these outgrowths has been masked in the present case by the great changes undergone by the rock. Professor Judd,[1] from a study of similar outgrowths on felspar crystals from the Western Isles of Scotland and elsewhere, came to the conclusion that the majority of such additions took place whilst the felspars were fresh and unaltered, and that in the Scotch case the outgrowths took

1 Quarterly Journal of the Geological Society, London.

place at the expense of the original glassy ground mass. He mentions that in certain specimens of rocks from New South Wales received by him from Professor David, the outgrowths apparently took place after advanced kaolinisation of the original crystals. In the Walhalla specimens, the latter remarks apply equally well, with the substitution of sericitisation for kaolinisation.

A moderate amount of interstitial quartz, containing fluid and glass inclusions, is present in this section. It is doubtful whether the quartz is primary or not. Considerable changes have taken place in the rock, and it is possible that the quartz was formed at the time of the amphibolitisation of the original femic mineral which was probably augite. A little chlorite (pennine) occurs replacing the hornblende, specimen W4, from same locality as W2. This rock resembles the preceding one very closely. Quartz however is rare. Sub-ophitic hornblende, and plagioclase laths predominate. The plagioclase appears to be present in two generations. An analysis of this rock for silica and alkalies gave the following result:—

SiO_2	... ...	52.99	per cent.
K_2O	... ...	2.09	per cent.
Na_2O	...	3.21	per cent.

The analysis confirms the microscopical determination of the rock as a hornblende diabase, or according to Harker's nomenclature, a hornblende dolerite. Since the hornblende is secondary, presumably replacing augite, the rock may be described as an epidiorite. No unequivocal potash felspar is present in the section, so that the relatively high percentage of potash indicated in the analysis, is probably due to the extensive sericitisation undergone by the original felspars.

Basic spherulite (? variolite).

In hand specimen, this rock is compact and aphanitic, and green in colour. No vesicles are seen even with the aid of a lens, and in only one specimen collected was there any evidence of varioles.

Section W6, pebble in conglomerate; section on road to the Jubilee Mine. Examined microscopically, it is seen that the rock is composed almost entirely of beautifully developed, sheaf and fan like, and occasionally spherulitic aggregates of hornblende and felspar. Phenocrysts are practically absent, as are also true varioles marked off from the ground mass. According to the definition of Professors Cole and Gregory,[1] " a variolite is a devitri-

fied spherulitic tachylyte, typically coarse in structure." The latter phrase of which was interpreted by Miss Raisin[2] to probably mean that spherulites were visible macroscopically. The Walhalla rock therefore differs from the typical variolite in the absence of macroscopically visible spherulites or varioles. The hornblende is entirely actinolite, and it usually occurs as long microlites frequently crossing one another. Examined under the high power, many of these microlites are seen to be skeleton crystals, and they very often enclose a tubular core of ground mass material showing very low polarisation colours. The edges of the microlites are often greatly serrated, and they usually fork at the ends, and pass gradually into the ground mass of the rock. Cross sections of these laths of actinolite occur in the form of small parallelograms, with central inclusions, corresponding to the tubular inclusions present in the microlites. The actinolite laths show a characteristic cross fracture at right angles to their length, and more rarely a cleavage parallel to their elongation. Twinning according to the usual law is not infrequently present. Both these microlites and the spherulites appear to be essentially contemporaneous in origin. At times the laths intersect the spherulites, but often the reverse is true, and the spherulites cut across, or project into the actinolite laths. Chlorite replaces much of the actinolite. The felspar laths give maximum extinction angles of 25°. They exhibit undulose extinction, and are sericitised in places.

Section W8, of pebble from same locality as the preceding specimen. This is an intermediate type between the normal diabase and the spherulitic rock. Microscopically, it consists almost entirely of hornblende and felspar laths, with secondary chlorite. The long microlites of actinolite show the characteristic serrated edges, and the central tubular inclusion of the ground mass. One or two grains of the hornblende retain the rectangular cleavage of augite, clearly proving the secondary origin of the former mineral. The felspar laths are usually only simply twinned, and they are occasionally zoned. Extinction angles are generally low, but angles as great as 40° were measured on isolated sections. The felspar in places includes hornblende, and in others penetrates the femic mineral, showing that both minerals are essentially contemporaneous in origin. The chlorite is markedly pleochroic, in shades of green and yellow. One section gave an

1 "The Variolitic Rocks of Mont Genèvre." Q.J.G.S.. London, 1890, p. 330.

2 "Variolite of the Lleyn and associated Volcanic Rocks." Q.J.G.S., London, 1893, p. 155.

extinction angle of 7 degrees from the 001 cleavage. It is distinctly biaxial, having a fairly wide axial angle; is negative; and is referable to clinochlore. A little disseminated pyrites occurs throughout the section, and is associated with brown iron oxide. True spherulites are absent from the rock, but plumose aggregates of hornblende and felspar are common.

Section W5 is practically identical with W6, except that the spherulitic structure is not so well developed. Veinlets of quartz and chlorite, with a little brown oxide, traverse the rock.

Section W3, of a pebble from same locality as the foregoing specimens. Microscopically, the texture is aphanitic, with the exception of a few porphyritic crystals of felspar. These appear to be entirely calcic felspar, giving maximum extinction angles of 43° from the twin planes. The basis of the rock is not easily deciphered, but it appears to consist of plagioclase, grains of black iron oxide, and ? augite. Vesicles infilled with chlorite are rarely present. The rock is probably a basic volcanic, approaching a basalt.

Section W9, pebble in conglomerate, near steel bridge over Thomson River, is a highly chloritised, sericitised and carbonated rock, probably a diabase. Apparently both plagioclase and orthoclase are present in the section; chlorite (pennine) replacing ? femic mineral; quartz showing strain effects and a little biotite and ilmenite.

Summary.

A series of conglomerates, grits, and limestones, containing igneous pebbles and debris, occurs near the Thomson river, Walhalla. Certain previous explanations, of the origin of the conglomerate, and of the igneous material, appear to be unsatisfactory. It is shown that the explanation, which maintains that the conglomerate is derived by post Silurian faulting and brecciation of an accompanying dyke, is at variance with the field relations; and also that there is little evidence of vulcanicity contemporaneous with the deposition of the sediments. The writer concludes that the conglomerate is a normal marine shore line deposit, and that the igneous debris present in the conglomerates and limestones is derived from pre-existing igneous rocks.

Petrologically, the pebbles show considerable similarity. All intermediate stages between a hornblende diabase (epidiorite), and the spherulitic type of the same rock are represented in the

pebbles collected. Pebbles of hornblende gneiss, quartzite, limestone, slate, sandstone and chert are also present in the conglomerate.

EXPLANATION OF PLATE.

PLATE II.

Fig. 1.—Microphotograph of hornblende diabase pebble, No. W2, showing two successive outgrowths from an idiomorphic felspar phenocryst Ordinary light × 25.

Fig. 2.—Microphotograph of spherulitic diabase, No. W6. Ordinary light × 25

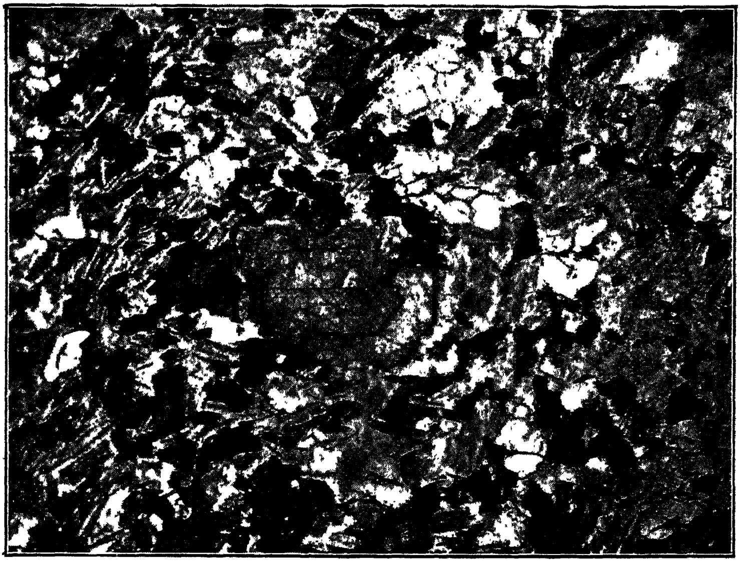

Fig. 1.

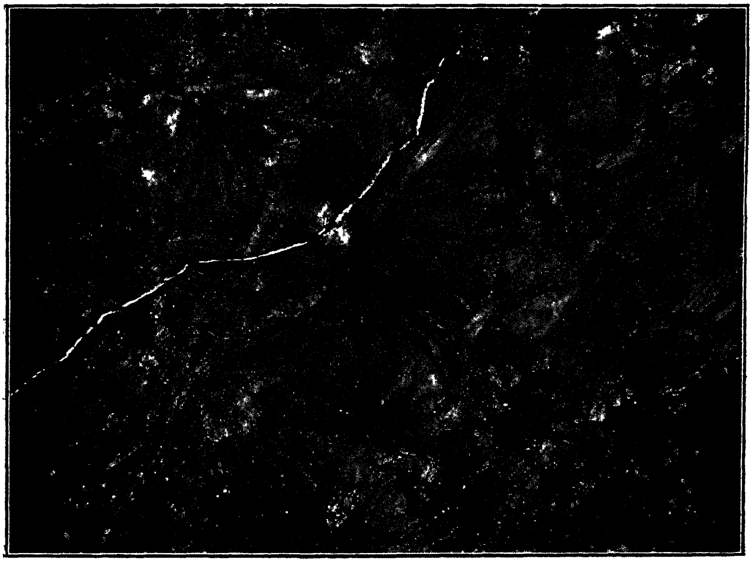

Fig. 2.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PT. II., 1914.]

ART. XX.—*Contributions to the Flora of Australia, No. 22.*[1]

BY ALFRED J. EWART, D.SC., PH.D.

(Government Botanist of Victoria and Professor of Botany and Plant Physiology in the University of Melbourne).

[Read 12th November, 1914].

ANAGALLIS ARVENSIS, L. "Pimpernel." (Primulaceae).

Recently responsible for the death of 23 cage birds at an aviary in Mentone. The birds were given a few handfuls of chickweed, containing Pimpernel. Next morning 23 out of about 100 birds were dead.

ANTHISTIRIA IMBERBIS, Retz (1779-91), (A. AUSTRALIS, R. Br., 1810), (A. FORSKALII, KUNTH., 1835), (THEMEDA FORSKALII, Hackel, 1885). (Gramineae). "Common Kangaroo Grass."

A native to Australia, South Africa, and Asia. This perennial grass is given under A. ciliata, L. in Bentham's Flora Australiensis, but Linnaeus' species is an annual Indian plant. It has also been termed *A. vulgaris* by Häckel in Engler's Pflanzen Familien, 11. Teil. 2. Abt. p. 29, 1887, but the oldest name has priority. The plant has had five different scientific names in 100 years, but the popular name has remained constant during the same period.

ANTIRRHINUM ORONTIUM, L. "Lesser Snapdragon." (Scrophulariaceae).

Ballarat. W. H. Bacchus; Camberwell, C. French (jnr.). October, 1913.

Previously recorded as a garden escape, but now appears to maintain itself when wild, and may be considered as naturalised. It is a native of Europe, Asia and Africa.

ARTEMISIA VULGARIS, L. "Mugwort." (Compositae).

Coode Island, Victoria. J. R. Tovey and C. French (jnr.). March, 1912.

Apparently in process of naturalisation. It is a native of N. Temperate regions.

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1. No. 21 in Proc. Roy. Soc. Victoria, vol. xxvi. (n.s.), p. 152, 1913.

Aster subulatus, Michx. "Shrub Aster." (Compositae).

Otukai, New Zealand. H. Carse, April, 1914.

A native of North America, widely spread as a naturalised alien in Victoria and New South Wales, but has not been hitherto recorded as growing wild in New Zealand.

Atropis magellanica or Atropis stricta? (Hook). Desv. (Gramineae).

Germantown, near Geelong, Victoria, H. B. Williamson, November, 1910.

This grass is a native of the southern part of South America, has only recently appeared, and is apparently sufficiently established to be considered naturalised, at least near Germantown. In regard to it Professor Hitchcock writes:—"The species of this genus are in great confusion, and it is difficult to identify them with certainty, until the group has been monographed. The three nerved upper glume of *A. magellanica* is unusual." This species has at different times been placed under Catabrosa, and also under Glyceria. The grass appears as though it would be of some value as a pasture plant, but nothing definite appears to be known from this point of view in regard to it. It has no injurious properties so far as is known at present.

Dr. Stapf writes:—"The spikelets agree very well with those of a specimen of Glyceria stricta, collected by Adamson, near Melbourne, in 1856, and fairly well with those of Hooker's type of Glyceria stricta from New Zealand, except that the joints of the rhacilla are generally longer, and the spikelets therefore laxer; but we have no samples with panicles equally loose. I wonder whether it can be a shade form. This could only be decided in the field or by experiment. Meanwhile the grass might be marked as Glyceria (Atropis) stricta, f. perlaxa."

Professor Hackel considers it to be Atropis stricta, Hack. var. tenuispica, Hack. ined (Glyceria tenuispica Steud.), a species found in Australia and New Zealand.

The position of this grass is for the present uncertain.

Avena barbata, Brot. "Barbed Oat Grass." (Gramineae).

Government Domain, Melbourne. Edwin Cheel, 9/1/1913.

A native of Arabia, Asia Minor, and the Mediterranean Regions, not yet sufficiently established to be considered naturalised.

CALADENIA CONGESTA, R. Br. "Slender Caladenia." (Orchidaceae).

Mt. Difficult, Grampians. J. W. Audas, 30/10/13.

The specimens have bronze to purple flowers. Bentham gives the flowers as 1-2 and pink. Luxuriant specimens also occur with pale or purplish perianths, and they may have up to three or four flowers.

CENTUNCULUS MINIMUS, L. "Chaff Weed" (Primulaceae).

This tiny plant is not recorded in Bentham's Flora Australiensis, and in Baron von Mueller's Census is recorded as Australian. In the Key to Victorian Plants, it is given with the native plants, but with the proviso, "possibly immigrated." The plant was first collected in 1883 at Mt. Macedon as *Anagallis centunculus*, and since then has been found as Hawkesdale (1899, F. M. Reader and H. B. Williamson, and at Mentone, C. R. Roberts, 1910). It is possibly more widely spread, but overlooked on account of its small size. There can be no doubt that it is a naturalised alien in Victoria, and not an original member of the native flora. In Engler's Pflanzenreich (Primulaceae, 1905), it is recorded from Europe, Asia, Africa, North and South America, but not from Australia.

CONRINGIA ORIENTALIS, Donn. "Hare's Ear." (Cruciferae).

Warracknabeal, Borung Shire, Oct., 1913. St. Eloy Dalton, Nov., 1904.

First recorded a garden escape, near Dimboola, and now apparently naturalised. A freely seeding annual, apt to smother seedlings in cultivated land, but not poisonous, or specially injurious.

CYNOSURUS ECHINATUS, L. "Rough Dog's-tail." (Gramineae).

Drouin, February, 1913. W. G. Anderson and H. J. Lindsay.

This grass is a native of Europe, which appears occasionally on the shores of Great Britain. It appears to have definitely established itself as a naturalised alien, and to be growing plentifully in at least one district of Victoria. The plant is an annual, and less valuable as a pasture grass than the Crested Dog's-tail (Cynosurus cristatus, L.), which is a perennial.

Diuris maculata, Sm. "Leopard Orchid." (Orchideae).

Vereker Range, Wilson's Promontory. J. W. Audas. August, 1914.

Previously recorded for Sealer's Cove by F. v. Mueller.

Eragrostis curvula, Nees, var. validа, Stapf. "African Love Grass." (Gramineae).

Between Drouin and Warragul, Vict. W. G. Anderson, Feb., 1913.

This puzzling grass, which could for a long time not be referred to any described species of Eragrostis, is considered by Mrs. Agnes Chase to be the variety described by Stapf. It is a native of South Africa, and the ordinary forms are sometimes grown as fodder plants. When old, however, the stems are rather fibrous and the foliage scanty. It can hardly as yet be regarded as definitely naturalised.

Erechtites Atkinsoniae, F. v. M. (Compositae).

Otukai, New Zealand. H. Carse, April, 1914.

Not previously recorded as growing wild in New Zealand. It is a native of New South Wales and Queensland.

Erechtites valerianaefolia, D. C. (Compositae).

Otukai, New Zealand. H. Carse, April, 1914. A native of North America not previously recorded as introduced in New Zealand. This plant has been recorded as a naturalised alien in New South Wales, but has not yet made its appearance in Victoria.

Erigeron canadense, L. "Canadian Fleabane." (Compositae).

Orbost. N. Wellington, 23/3/1914.

A widely spread naturalised alien first recorded as naturalised in 1908, and which has now reached the Orbost district.

Gladiolus grandis, Thunberg. (Iridaceae). The Large-flowered Gladiolus.

A native of S. Africa, which was recorded as a spreading garden escape at Eltham in 1911, and has now appeared in thousands along a drain at Digger's Rest, on the Bendigo line. (C. French, Jr., Oct., 1914.)

The perfume is very strong, not unlike the scent of primroses. The plant does not seem to have any obnoxious qualities, but many

of the Irideae are poisonous, and hence objectionable in pastures. It may now be regarded as an established naturalised alien.

GOMPHRENA CANESCENS, R. Br. (Amarantaceae).

Herbert Bros.' Station, No. 2, Darwin. G. F. Hill, 28/5/13. This plant has reddish-purple heads and seems worthy of garden cultivation. The heads of the ordinary form are usually pale in colour.

HELIPTERUM GUILFOYLEI, Ewart. Proc. Roy. Soc. Victoria, vol. xx. (n.s.), p. 82, 1907=H. ZACCHEUS, S. le Moore. (Compositae).

Mr. Spencer le Moore writes that the achenes of this plant differ only from those of H. Zaccheus, S. le Moore, in being rich brown instead of dark slate colour and slightly shorter, and also finds the same peculiar mucilaginous layer in H. Zaccheus that was first described for H. Guilfoylei. The latter, therefore, becomes a synonym to the former.

HYDROCOTYLE MEDICAGINOIDES Turcz. "Trefoil Pennywort." (Umbelliferae).

Miss J. E. Tilden, No. 811. Point Lonsdale, Nov., 1912. Not previously recorded for the south of Victoria.

HYOSCYAMUS ALBUS, L. "White Henbane." (Solanaceae).

Williamstown, Victoria. C. French, junr., Oct., 1913.

Noted as a garden escape at Cashel nearly 20 years ago, and now definitely naturalised. The fruit is peculiar, opening by a lid. In ancient times this plant was regarded as a sacred plant, and sometimes smoked like tobacco as a preventative for toothache. It belongs to a poisonous genus, and contains a hypnotic and deleriant poison, hyoscyamin, but appears to be much less poisonous than the black Henbane, *Hyoscyamus niger*.

LINARIA ELATINE, L. "Hairy Toad Flax." (Scrophulariaceae).

Spreading in the Werribee district. C. French, junr., Oct., 1913.

LIPPIA NODIFLORA, Mich, var. SARMENTOSA. (Verbenaceae).

Williamstown. J. R. Tovey, Jan., 1914.

The plant grows in dense mats in the gutters and has evidently been introduced by foreign shipping. It is a common tropical

weed, and has been used for lawns in Egypt, where grasses and ordinary lawn plants fail.

MORGANIA GLABRA, R. Br. "Smooth Morgania." (Scrophulariaceae).

Myall, near Kerang. Miss Sheehan (H.B.W. No. 1465.)

Not previously recorded as Victorian. Baron von Mueller included all the species of Morgania with *Stemodia viscosa* as *Stemodia Morgania*, and hence the distribution of the species of *Morgania* now recognised is not easy to trace, but no previous specimens of it or records of it from Victorian localities can be found.

OLEARIA RAMULOSA, Benth., var. INTERMEDIA, A. J. Ewart. New variety. (Compositae).

J. W. Audas. Grampians, 1914.

This form has the leaves of the type and the small heads of (Aster) *Olearia microphylla*, Vent., thus justifying Bentham's inclusion of this species as a *variety of O. ramulosa*. Baron von Mueller maintained both species in the Census, although Bentham noted the small flower heads of the Grampians form.

It is apparently a mountain variety, whereas other intermediate forms which come nearer to the variety *microphylla* are coastal plants (Portland, etc.).

ONONIS SPINOSA, L. (Compositae).

Cobden, C. A. Ogilvie, 1913.

This weed, the "Spiny Restbarrow," a native of Europe, may now be considered to be definitely naturalised. Though practically useless as a fodder plant, it usually grows on the poorer soils, and since it is easily destroyed by cultivation, is hardly to be regarded as a serious weed.

ORTHOCERAS STRICTUM, R. Br. "Crow Orchid." (Orchidaceae).

Head of Barry's Creek, Wilson's Promontory. Messrs. Pitcher and Audas, Dec., 1912. Not previously recorded for the National Park.

PHYSALIS VISCOSA, L. "Sticky Cape Gooseberry or Ground Cherry." (Solanaceae).

C. C. Brittlebank, March, 1913.

Growing in such abundance as to be almost a pest. The plant, which has already been recorded as an exotic, may now be regarded as definitely naturalised.

PINUS INSIGNIS, Doug. Monterey Pine." (Coniferae).

Between Beaconsfield and Emerald. J. W. Audas and E. E. Pescott, 1913. Upper Beaconsfield. J. R. Tovey, August, 1914.

This tree is now evidently establishing itself as a naturalised alien in many parts of Victoria, especially in the Beaconsfield and Emerald districts. It spreads from wind-borne seeds developed on planted trees.

PRASOPHYLLUM FLAVUM, R. Br. "Yellow Leek Orchid." (Orchidaceae).

Mt. Baw Baw. C. French, junr., January, 1914.

A native of New South Wales and Queensland not previously recorded for Victoria.

PRASOPHYLLUM SUTTONI, Rogers and Rees. "Alpine Leek Orchid." (Orchidaceae).

Mt. Baw Baw. C. French, junr., January, 1914.

A native of Victoria previously only recorded from the Buffalo Plateau.

PROSTANTHERA DENTICULATA, R. Br. "Rough Mint Bush." (Labiatae).

Hall's Gap, Grampians, Victoria. Miss J. E. Tilden, No. 962, Dec., 1912.

In Mr. Campbell's "Census of Grampian Plants" (Vict. Nat., Vol. XXVIII., p. 108, 1911) footnote, it is stated that this species does not occur in the Grampian Mountains. It was, however, recorded from the Grampians by Baron von Mueller, and still grows in fair abundance.

RANUNCULUS OPHIOGLOSSIFOLIUS, Vil. "Snake tongue Ranunculus." (Ranunculaceae).

Haddon, between Linton and Ballarat. H. B. Williamson, Dec., 1912.

This British plant is a native of West Europe and the Mediterranean regions. The plant is growing wild in fair abundance and may be regarded as definitely naturalised.

RESEDA LUTEA, L. "Cut-leaved Mignonette." (Resedaceae.)

Regnella, Sth. Australia. T. G. Osborn, Sept., 1913.

This plant is a native of Europe, especially in limestone districts. This is a new record for South Australia, but Professor

Osborn informs me he has since visited the locality and rooted out the plant. It will be interesting to see whether it reappears in the same or other localities.

SALIX CAPREA, L. "Sallow Willow." (Salicaceae).

Leongatha. J. M. Molloy, 15/8/14.

A native of Europe and Asia, growing usually near water. It is occasionally planted and has thence run wild, appearing to hold its own in the native scrub, particularly on river banks or near water.

THELYMITRA VENOSA, R. Br. "Veined Hood Orchid." (Orchidaceae).

Mt. Baw Baw. J. G. O'Donoghue and C. French, junr., Jan., 1914.

A native of New South Wales and South Australia, not previously recorded for Victoria.

TRITONIA LINEATA, Ker. "Pencilled Tritonia." (Irideae.)

Charlton, Nov., 1913.

Already recorded as a garden escape at Geelong, and apparently in process of becoming naturalised.

VICIA TETRASPERMA, Moench. "Slender Vetch." (Leguminosae).

Along the railway enclosure at Glen Iris, fairly abundant and away from cultivation paddocks. W. G. Anderson, Nov., 1912.

The plant has previously been recorded as an exotic and may now be regarded as definitely naturalised. It is a native of Europe and W. Asia, from Mediterranean to Arctic. The present form approaches towards the variety *gracilis*, but has the shorter pods of the type.

ZYGOPHYLLUM OVATUM, Ewart and White. "Dwarf Twinleaf." (Zygophyllaceae).

Ouyen. H. B. Williamson, No. 1468, Sept., 1913.

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ART XXI.—*Certain Suffixes in Oceanic Languages.*

BY W. G. IVENS, M.A.

(Communicated by R. D. BOYS, M.A.).

1.—Nature of the Enquiry.

Four Tables have been compiled by the writer, showing:—

Table I.—Verbal Suffixes	in certain Oceanic Languages.
Table II.—Noun Suffixes	
Table III.—Passive Suffixes	
Table IV.—Adjectival Suffixes	

After each Table instances are given of words which show the presence of such Suffixes with remarks thereupon, and such conclusions are drawn as seem to be warranted by the evidence adduced.

2.—Object of the Enquiry.

(a) To collect instances of Verbal and Noun Suffixes occurring in languages where their presence has not been recognised hitherto,

(b) To form a theory that will give a satisfactory explanation of the formation of the Gerundives and of the Passive Suffixes in Polynesian.

Note.—*n* is sounded as *ng* in singer. Abbreviations: v.—verb; v.i.—verb intransitive; v.t.—verb transitive; adj.—adjective; n—noun; adv.—adverb; prep.—preposition; Pol.—Polynesian.

TABLE I.

Verbal Suffixes.

This Table is founded on the Table of Verbal Suffixes in Dr. Codrington's "Melanesian Languages," p. 180. New features in it are—(1) Nguna, (2) Gilbert Islands, (3) Rotuma, (4) Maori, (5) Samoan, (6) Tongan, Tahitian, Hawaiian, (7) Malay (8) Ulawa, Sa'a, Wango lists have been amplified, (9) Lau, (10) Melanesian New Guinea (Expedition to Torres Straits, Vol. iii., p. 458), (11) New Britain.

	Consonantal.	Syllabic.
	(a) Loyalty Islands.	
Nengone	*ne*, *ni*, *ti*	-
Lifu	*n*	-

	Consonantal.	Syllabic.
	(b) New Hebrides.	
Anaiteum		rai, raig; jai, jaig; naig, taig; haig
Fate	i, ki, ri, si, ti	aki, faki, maki, naki, raki, sai, saki, taki
Sesake	i, ki, ti, vi	raki
Nguna	i, gi, ki, mi, ni, si, ti, vi	raki, sai
Ambrym		ta
Espiritu Santo	ni, vi	tag
Araga	i	mai, rai, tai
Oba	hi, si	tagi
Maewo	gi, si	nagi, va, vagi
	(c) Banks' Islands.	
Merlav	n, r, t	la, na, ra, va
Gaua	g, n, n, r, s, t, v	gag, lag, nag, rag, sag, tag
Vanua Lava	g, n, n, r, t	me, leg, re, se, te, teg, ve
Mota	g, n, n, r, s, t, v (na, sa)	ag, gag, lag, mag, nag, nag, rag, sag, tag, vag
Motlag	g	heg, geg, teg, veg
Volow	g, r	hea, nia, rea, tea, vea
Ureparapara	n, v	ran, sa, te
Torres Islands	g, j, t	ga, te
	(d) New Britain.	
	k, n, t	
	(e) Fiji.	
	a, ca, ga, ka, ma, na, ra, ta, va, wa, ya	caka, kaka, laka, maka, raka, vaka, waka, yaka
	(f) Gilbert Islands.	
	a, 'i, ka, na, ta, ba	ba'i
	(g) Rotuma.	
	ki	
	(h) Maori.	
	i, hi, ki, mi, ni, ni, pi, ri, ti (ta, na, rana)	
	(i) Samoan.	
	i, 'i, fi, li, ni, ni, si, ti, vi (ta, va)	a'i, fa'i, ga'i, ma'i, na'i, la'i, sa'i, ta'i, tani, va'i

Consonantal. Syllabic.

(j) Tongan.

i, ki, hia, mi, fi

(k) Tahitian.

i, hi, mi

(l) Hawaiian.

i, ki, ni

(m) Malay.

i, k, m, t, si, kan

(n) Solomon Islands.

Ulawa	*'i, hi, li, mi, ni,* ni, *ri, si (la, na)*	*a'i, a'ini, ha'ini, la'ini, ma'ini,* na'*ini, ra'ini, ta'ini*
Sa'a	*'i, hi, li, mi, ni,* ni, *ri, si (la, na)*	*a'i, a'ini, ha'ini, la'ini, ma'ini, na'ini,* na'*ini, ra'ini, ta'ini*
Lau	*'i, fi, li, mi, ni,* ni	*a'i, fa'ini, ma'ini,* na'*ini, ta'ini*
Fagani	*si*	*vagi*
Wango	*'i, hi, mi, ni,* ni, *ri, si*	*a'i, fa'ini, ma'ini,* na'*ini, ta'ini*
Vaturanga	*hi, li, mi, ni, si, vi*	*vahi*
Florida	*hi, li, mi, ni,* ni, *si, ti, vi*	*hagi, lagi, pagi, sagi, vagi*
Savo	*li*	
Bugotu	*hi, ni, ri, ti, vi*	*hagi, lagi, vagi*
Gao	*ni, z*	
Duke of York	*i, m*	*pai, tai, rai, uai*

(o) Melanesian New Guinea.

Roro	*na, ni*	
Mekeo	*ni*	
Notu	*i, hi, di, li, ni, ri, (a, ta, na, sa)*	*bai, dai, hai, lai, mai, nai, rai, tagi, agi, giagi*
Suau	*i*	
Kiriwina	*ki*	
Wedau	*ai, ei, oi, ui, gi, ni*	
Tavara	*i, e*	
Mukawa	*i, ni, si, vi*	

NOTES, ETC., ON TABLE I.

Dr. Codrington, "Melanesian Languages," p. 177, gives the following definition of the use and the nature of Verbal Suffixes. "The Verbal Suffix marks the word as a Verb. All Verbs have not Suffixes; a Suffix is added to a Verb to change in some way its signification. It may very well be that a Verb with a suffixed termination may be found in a language in which the Verb without a Suffix is not found at present, but the stem is a Verb, and the signification of the Suffix will be felt in the meaning of the word." This quotation applies directly to the use of these Suffixes in the Melanesian languages. While the same Suffixes may be clearly seen attached to Verbs in the Polynesian languages, yet it is very evident that the Polynesian peoples do not regularly employ these Suffixes in the same way or to the same extent in which they are employed in Melanesia. However, instances given below from Samoan and from Maori show certain uses of the Verbal Suffixes directly corresponding to uses in the Melanesian languages.

The Verbal Suffixes are attached in the Melanesian languages to Verbs, Nouns, Adjectives, Adverbs, their function being to make a Neuter Verb definitely transitive, or to increase the transitive signification of a Verb already transitive, or to fix its action on to a certain object, or to mark a word as a Verb. In this latter capacity the Verbal Suffixes are attached to Nouns, Adjectives and Adverbs. No instance has been collected of a Verbal Suffix added to an undoubted Adjective in any Polynesian language, and it may well be that the Adjectives in Sa'a and Ulawa, to which Verbal Suffixes are added, *paine* big, *maimei* small, *haora* (Ulawa), small, are really Verbs, and that the Verbal Suffixes are not really added to pure Adjectives, and in all probability the so-called Adverbs to which the Suffixes are added are really neuter Verbs.

It is unnecessary for the purpose of this enquiry to quote the examples of Verbal Suffixes that are given in the languages treated by Dr. Codrington in "Melanesian Languages," and accordingly examples will be given in those languages only which the writer has himself added to the Table, or which have been amplified.

(1) *Verbal Suffixes in the language of Nguna.*

These have been collected from the translation of the Gospels according to S.S. Matthew and John.

Maworawora adj. broken, *mawori* to break, (c.f. Mel. Lang., p. 461); *munu* v.i. to drink, *munugi* to drink of; *marimatagi* v.t. to

prepare, (Mota *matemate* ready); *matauki* v.t. to fear (Ulawa *ma'au*, *ma'auni*); *tinomi* to swallow; *roromi* to love, (Mota *lolo* heart, affections); *samasama* n. glory, *samasamani* to glorify; *punusi* prep. to, v.t. to see, (c.f. Ulawa *loosi*, and Florida *punusi*); *puluti* to seal (Ulawa *pulu* n. pitch, *pulu'i* to pitch); *tatano* to beseech, *tatanovi* to ask.

Certain Verbs in Nguna seem to have Suffixes compounded of two forms; *nati* to throw, *natiki* and *natikini* to cast, *noa* to say, to speak, *noasai* and *noakisai* to declare. Dr. Codrington ("Mel. Lang.," p. 465) questions whether *ki* in Sesake is a Verbal Suffix, and in the following instance separates *ki* from the Verb *sapura*, *soro sapura ki na lepa*, sweep away the dirt. He adds, however, that *sapuraki* resembles the Mota *savrag*, and is used in Nguna as meaning to sow; *savrag* itself being made up of *sav* to sow, and *rag*, Verbal Suffix. Since *ki* occurs in Nguna, a neighbouring island, it probably occurs also as a Verbal Suffix in Sesake, and *raki* certainly occurs in Nguna as a Verbal Suffix, and *liniraki* to leave, abandon, shows an undoubted instance of *raki* as a Syllabic Suffix, c.f Sa'a *liki* to cross, go beyond, leave; Florida *liligi* beside, to pass by.

(2) *Verbal Suffixes in the language of New Britain.*

Arik to split, Mota *ari*; *telek* to peck at, Mota *tere*; *likun* to bend, Mota *luk*; *kolot* to scold, Mota *gol*.

(3) *Verbal Suffixes in the language of the Gilbert Islands.*

Mata n. eye, *matai* to look covetously at; *boba* to trade in oil, *bobai* to trade; *mana* a branch, *manai* a spear with branches; *uruuru* to engage in destroying, *urua* to destroy, *uruba'i* to engage in destroying; *okai* a house for storing coconuts, *okaia* to store coconuts; *kauka* to open, (Sa'a *hu'e* to open, *hu'esi*, Samoan *sua* to grub up, Maori *huaki* to open); *moti* adj. broken off, *motika* to break; *buti* to go along, *butika* to meet (c.f. Sa'a *odo* to journey on, *odo'i* to meet); *ua* to swim, *uana* to swim out to; *tabu* to forbid, *tabuna* to make taboo; *ruo* to descend, *ruona* to descend to; *inoa* a namesake, *inoana* to name after; *rao* a companion, *raona* to associate with; *kori* v.t. to scratch, *korita* v.t. to scratch; *raba* adj. secret, *rabata* to approach cautiously in order to seize; *bono* adj. shut, *bonata* to close; *rabata* n. the body, v.t. to embrace, *rabata* v.t. to embrace; *urina* to remember, *urinaba* to remember with affection or sorrow.

All of these instances are thoroughly after the Melanesian style, and Verbs, Nouns, and Adjectives have the Verbal Suffix attached. The Adjectives are probably neuter Verbs.

(4) *Verbal Suffixes in the language of Rotuma.*

In the grammar of Rotuma ("Mel. Lang.," p. 406) Dr. Codrington says:—"The transitive suffix *ki* appears in the Verb *alaki* kill, from *ala* to die."

(5) *Verbal Suffixes in Maori.*

The Verbal Suffixes can be clearly seen in Maori and are found attached to Verbs, Nouns, and so-called Adjectives. They have never been recognised by the Maori grammarians, and Dr. Codrington ("Mel. Lang.," p. 181) says that there is no suffix to the Verb in Maori. But as will be seen from the examples appended here, certain Verbal Suffixes have similar functions in Maori and in the Melanesian languages, though the impression given by a general study of the words in Maori which show the presence of a Verbal Suffix is that they are not used with anything like the force and power which they have in Melanesia, that, in fact, they have ceased in the main to be "Transitive Suffixes," nor does their addition to a word necessarily mark it as a Verb. Both Mota and Sa'a afford examples of the addition of the Transitive Suffixes to the Verb without thereby conveying a definite Transitive force; Mota *vura* to spring forth, *vuras* to come forth, *vuratag* to spring forth forcibly; *goro* to pass over, of sound, *gorot* v.i. to strike, come to the ears; *tale* to go round; *tallag*, v.i. to turn; *qoro* to throw down something heavy, *goron* to encounter anything severe. Sa'a *hure'i* to gush forth, Mota *vura* as above.

Examples: *mana* a branch, *manai* mouth (Fiji *mana* a mouth, c.f. Motu *haga* to gape, *hagai* to open the mouth, Lau *faga* mouth, Mota *wana* to gape, *wanai*, a gaping, *wanara* to branch, *wanarai* a branch); *taka* to fasten a fish hook, *takai* to wrap round; *uku* to wash with clay, *ukui* to rub; *horoi* to wash, (Tongan *holo* to wash, Samoan *solo soloi* towel); *pao* to strike with a hammer, *paoi* to pound (c.f. Sa'a *horo* to kill, *horo'i* to hit); *inoi* to beg, pray (Samoan *inoino* to demand, *Lau ino* to beseech); *punui* adj. close together (Samoan *punupunu* a cluster of parasitical plants, Sa'a *hunu* a bunch); *whawha* to lay hold of, *whai* settled, possessing; *pu* to blow, *puhi* to blow (Ulawa *'uhi*); *taka* to fall off, roll, *takahi* to trample; *aro* to face, *arohi* to examine; *ara* a path, *arahi* to

lead. These last two examples are quite in the Melanesian style, (c.f. Ulawa *na'o* to face, *na'ohi* to lead, to direct); *tapa* to pulverise, *tapahi* to chop (Sa'a *tapa* to strike, *tapali* to cut off, reap); *hua* to raise with a lever, *huaki* to open, uncover, (Sa'a *hu'e* to lever *hu'esi* to open, Samoan *sua* to grub, Tahitian *huai* to uncover oven); *mata* eye, *mataki* to watch, *matai* to seek to obtain by artifice, (Mota *mata* eye, *matag* to watch); *kaha* a rope, *kahaki* a strap, a master, (Tongan *kafa* sinnet, *kafakafai* to bind); *ruaki* to vomit, (Mota *lulua* v.i. to vomit, *luag* v.t., Marquesas *ua*, *uaki*, Malay *luat* to loathe); *nunumi* to disappear behind, (Sa'a *nunu* shadow); *horo*, *horomi to swallow*. (Samoan *folo* to swallow); *hau* to hew, to chop, *haumi* to join, a joint; *tanu* to bury, *tanumi* to fold double, to disappear behind, (Samoan *tanuma'i* to cover up with, *tanu* to bury); *koro* a noose, *korori* adj. twisted, v. to stir round; *taro* adv. a little while, *tarori* to pass away quickly, (c.f. Sa'a *ha'atau* far off, *ha'atauli* to be far off); *hokai* adj. spread out, *hokari* to stretch out the legs, to move by stretching the legs, (Florida *voka* to be open, Sa'a *hoka* to come apart, *hokasi* v.t. to burst open); *kopa* adj. bent, *kopani* to shut to, a lid, *kopaki* to wrap; *kapi* to be covered, *kapiti* adj. enclosed; *apiapi* adj. close together, *apiti* to place side by side (Samoan *apiapi* narrow, Sa'a *apiepi* to be contiguous to, Malay *apit* side by side); *ho* to pout, *honi* to sniff, to rub noses (Tahitian *homi* to sniff, Mangareva *aka-hoho* to lick, c.f. Sa'a *nono* to sniff, *nono'i* to kiss); *po* night, *poniponi* adj. dim; *titoni* to peck (Hawaiian *kiko* to dot, Marquesas, Tahitian *tito* to peck, Mota *tit* to strike off flakes); *meatinia* the passive of *mea*, shows a compound Suffix made up of *ti* and *ni*; *rau* a leaf, *raupi* to cover over.

Remarks.—There can be no doubt that the Verbal Suffixes appear in Maori, since the above examples definitely prove their existence. The use of such words as *hokai*, *kapiti*, *punui*, as Adjectives, may easily find a parallel in Melanesia, Sa'a *pele* adv. by mischance, *pele'i* adv. by mischance, *pelena'ini* to do by mischance, *lae* to go, *laehi* v.t. to travel through, *laelae'i* adv. *ere laelae'i* wayside talk; *ahu* to be complete, *ahu'i* prep. with suffixed pronoun, around; and as will be seen below the Syllabic Suffixes are used in Sa'a to form Participles, which may be considered as Adjectives. Melanesia offers no parallel to the use of such a word as *kahaki* as a Noun (c.f. however *gapulut*, glue, in Mota, where the final *t* is the Verbal Suffix), but it is not difficult to see how its use as a Noun has come about. Many words in Maori classed as Adjectives, e.g. *apiapi*, are

evidently Verbs (c.f. Mota *vanameag* waste, useless, where *ag* is a Verbal Suffix); while a word like *taro* a little while, which is classed as an Adverb, seems rather to be a Verb, also *ha'atau* in Sa'a which has been instanced above is rather a Verb, *ha'a* the Causative and *tau*, verb, to be far off, and the conclusion may be drawn that the so-called Adverbs to which the Verbal Suffixes are attached are really Verbs (c.f. Mota, *ninaninag* adv. bumping up and down, *nina* to knock).

Both classes of the Suffixes are used in Melanesia to form Participles, or, as they may be considered, Adjectives, Sa'a *pele'i* (as above), *oro* to stoop, *oroma'i* bowed together, *luhe* to loose, *luheta'i* loosed, *mou* to be broken, *moute'i* only, single.

Maori seems to use more than one Suffix with the same Verb, e.g. *kopa, kopani, kopaki; mata, matai, mataki;* this may be paralleled by Ulawa, *siki* to come off, be detached, *sikili* to twang with the fingers, *sikihi* to undo, *lae* to go, *laehi* to go through, *laeli wala* to make an oration; Mota *sogo, sogon, sogov;* but as a rule in Melanesian each Verb is used with its own particular Suffix.

It will also be noticed that a common use of these Suffixes in Maori is to convey thereby a slightly different signification to the meaning of the Verb, e.g. *tapa* and *tapahi*, this may be paralleled by Mota *sala* to boil, *salag* to cook with hot stones, but the common Melanesian use of these Suffixes, viz., to make a neuter Verb definitely transitive, etc., is not so common in Maori, though *aro, arohi* is an example of it.

Our conclusion is, therefore, that with the one exception of Verbs formed from Adjectives by the addition of the Verbal Suffixes (Sa'a *paine* big, *painesi* to be too big for) all the various characteristic uses of the Verbal Suffixes in Melanesia are found also in Maori, while in addition Maori has employed the Suffixes to form Nouns.

(6) *Verbal Suffixes in Samoan.*

The Samoan use with regard to the Consonantal Verbal Suffixes approximates very closely to the use of the same Suffixes in Melanesia. "In Samoan the termination *ta'i* or *sa'i* adds the sense of 'with' to the verb; *momo'e* to run, *mo'eta'i* to run with a thing; *'a'au* to swim, *'ausa'i* to swim with a thing." ("Mel. Lang.," p. 181.) But *ta'i* also conveys a particular transitive force, *lafi* to hide oneself, *lafita'i* to hide away, to conceal. In Sa'a we notice that the Syllabic Suffix also conveys the sense of "with," *huru* to run, *hurune'ini* to run with a thing; *olo* to swim, *olohi* to

swim for and get, *oloha'ini* to swim with and carry (c.f. Mota *tag, sag, vag;* Fiji *caka, taka*).

Examples.—*mua* first, *muai* to be first (Malay *mulamula* first. *mulai* to be first, also Mota *amoa* formerly *moai* to be first); *mamafa* weighty, honoured, *mamafi* to be honoured (c.f. "Mel. Lang.," p. 415: Maewo *weda* to be heavy, *wedei* to be heavy upon; also p. 465. Sesake *mawora* broken, *mawori* to be broken); *afa* sinnet, *afaafai* to bind with sinnet; *nofo* to sit, *nofoi* to be in a sitting posture; *mana* branch, *manai* to sit astride; *tapu* to make sacred, *tapui* a sign of tapu, to prohibit by a tapu mark; *sapasapai* to take in the arms (Mota *sapan*, Sa'a *'apala*); *pola* a plaited coconut leaf, *polani* to carry on a *pola; tusa* to be equal, *tusani* to divide equally; *lavalava* a loin cloth, *lavasi* to tie round and round; *motu* broken, *motusi* to break (Sa'a *mo'u* to be broken, *mo'usi* to break); *puluti* to pitch, to glue (Sa'a *pulu* pitch, *pulu'i* to pitch); *mata* eye, *matafi* to be swept away as clouds, to be open, clear; *poniponi* twilight, *poponi* to scowl, begin to be blind (Polynesian *po* night); *momo'e* to sleep, *mo'ega'i* to carry over night, i.e. to sleep with; *sili* adv. exceedingly, *silifa'i* to go beyond (Sa'a *sili* to enter, *silihe'i* to insert); *alo* to conceal, *alofa'i* to conceal; *punipuni* to shut in, *punita'i* to stop up with anything; *noga* to be quiet, *nogata'i* to desist; *tanu* to bury, *tanuma'i* to cover up with; *nofo* to sit, *nofoa'i* to sit and talk over news.

Verbs with the reciprocal prefix *fe* have *si, fi, ni, a'i, fa'i, ma'i, ta'i, na'i, va'i*, as Syllabic Suffixes, and *i, fi, ni, si*, as Consonantal Suffixes; *fe'ausi* to swim, *fetanofi* to take hold of; *feluani* to go two together; *fealofani* to love one another; *lata* to be near, *felata'i* to be near together; *felamata'i* to watch for one another (c.f. Ulawa *he'itotori*); *fetalia'i* to give answer (c.f. Sa'a *ala* v.i. to answer, *alami* to answer anyone, *he'ialama'i* to answer one another); *gagana* to speak, *fegaganava'i* to speak to one another; *utu* to draw water, *feutufa'i*.

The Noun Suffix *na* may be added to the Verb when used with either the Consonantal or the Syllabic Suffix, *nofo* to sit, *nofoa'i*, *nofoa'ina* a sitting; *afi* to do up in a bundle, *afisi* to carry under the arms, *afisina* an armful; but in Melanesia the Noun Suffix is attached only to the Consonantal Verbal Suffix, Sa'a *usu* to push, *usune'i* to send, *usune'ine* a commandment. But if Dr. Macdonald's example from Fate be correct, *na bulutian ni na suma* the plastering of the house, then the Samoan use has a perfect parallel in Melanesia.

Our conclusion is that all the various characteristic uses of the Verbal Suffixes in Melanesia, with the same exception noted in Maori., viz., Verbs formed from Adjectives by the addition of the Verbal Suffix, are found also in Samoan. In addition we note the use of the Consonantal Suffix with the reciprocal *fe* (seen also in Sa'a), and the Consonantal Suffix forming a Noun from a Verb, *tapui*, *poniponi*. This last use can be readily accounted for as in Maori by the word thus formed being used to describe both the action and also the name of the action.

(7) *Verbal Suffixes in Tongan, Tahitian, and Hawaiian.*

Tongan,

holo to wipe, *holoi* to wipe; *kafa* sinnet, *kafakafai* to wrap sinnet round anything; *huai* to turn up, *huahuai* to uncover (Samoan, *sua* to dig, etc.); *buaki* to vomit (Maori *pua* foaming); *mataki* to spy (Oceanic *mata* eye); *homi* to sniff (Maori *ho*, *honi*, as above); *anuhia* to spit on (Mota *anus*, Samoan *anusa*); *ala* to touch, *alafi* to feel after the hand. Mr. Ray, "Common origin of the Oceanic peoples," gives *aki* as a Verbal Suffix.

Tahitian,

tapahi to split breadfruit (Maori *tapa* to pulverise, *tapahi* to chop; Sa'a *tapa* to strike, *tapali* to cut off); *ruai* to vomit (Mota *lulua*, *luag*; Maori *ruaki*); *mataitai* to examine (Oceanic *mata* eye); *homi* to sniff (Maori *ho*, *honi*); *horomi* to swallow (Maori *horo*, *horomi*).

Hawaiian,

puai to spout (Maori *pua* foaming); *luai* to vomit; *huai* to open; *holoi* to wash; *kahai* to bind, girdle (Polynesian *kaha* sinnet); *kiko* a dot, *kikokikoi* irregularly; *honi* to smell; *iniki* to pinch (Oceanic *gini*, *'ini*).

(8) *Verbal Suffixes in Malay.*

Minum to drink (Sa'a *'inu*, *'inumi*; Nguna *munu*, *munugi*); *apit* to be side by side (Maori *apiapi*; Sa'a *apiepi*); *apit-kan* a press; *luat* to loathe; *ambusi* to puff out from the mouth (Mota *pupus* Pol. *pupuhi*); *mulamula* at first, *mulai* to be first; *susu* milk, *susui* to suckle; *panas* hot, *panasi* to heat; *penoh* full, *penohkan* to fill; *lapis* a fold, *lapiskan* to line; *tangis* to weep (*Po tani*).

Dr. Codrington ("Mel. Lang.," p. 181) says that the Verbal Suffixes are looked for in vain in Malay, and that they are not apparent in Tongan, and that he has no knowledge of their exist-

ence in Tahitian and Hawaiian. However, the above examples clearly show the presence of these Suffixes in all the four languages. But there can be no doubt that the Suffixes do not play the important part in these four languages which they play in Melanesia, or in Samoan.

(8) *Verbal Suffixes in the Solomon Island Languages.*

For the purpose of this Paper it will not be necessary to give instances of words showing the ordinary way in which the Verbal Suffixes are used in the Solomon Island languages; a full account of their use in Florida is given in "Melanesian Languages," and the present writer has done the same for Sa'a and Ulawa and Lau in his grammars of those languages.

No very satisfactory explanation can be given of the termination *ni* in the Syllabic Suffixes in Ulawa, Wango, Sa'a, Lau, Florida. Dr. Codrington ("Mel. Lang.," p. 532) speaking of its use in Florida with the Verbal Suffixes, calls it a Preposition and refers to the use of *ni* in Oba, where it is compounded with the Preposition *gi* (Polynesian *ki*). The Florida *ni* occurs also as an Instrumental, but in the Eastern Solomons in Sa'a, etc., *ni* is used only as a Genitive, the Instrumental being *ana* or *ani*. It is possible that the Instrumental *ani* may be formed from *nia* by metathesis, and that *nia* is compounded of *ni* prep. and *a* suffixed pronoun.

Lau and Wango use the Syllabic forms in an Active sense, i.e., a Pronoun is added as an anticipatory Object, without the necessity of adding *ni* to the Suffix; Lau *gonita'i* v.t. to receive; *gwouta'i* or *gwouta'ini* to incline the body; *oalana'i* to distribute; *fatolama'i* to command (Sa'a *ha'atolana'ini*); Wango *poota'i* to beseech. In Ulawa and Sa'a when *ni* is omitted after the Suffix the Verb has no transitive force, *kire ko kelite'i honotamu* they stand in a circle round you; *ta'e* to raise, *ta'ela'i* v.i. to set out, start, make a beginning; and when the Verb with Suffix is separated from its Object the *ni* is dropped and the Possessive is used as the Object instead of the Suffixed Pronoun; *kire ke su'uhe'i mano ada* they will completely destroy them; *mane 'o ha'apolaha'i saewasu ana mane i'oe* chasten not thy servant in thy displeasure.

In Ulawa, Wango, Sa'a and Lau, there is an adjectival or participal use of the Syllabic forms in *a'i* without *ni* added; Sa'a *honule'i* Wango *honura'i* full of; Sa'a *tekela'i*, Lau *tegela'i* lost, *tarau* continuously, straight on, *taraure'i* continuously. Also *ha'idenie'i* till daylight. Also in Lau the Syllabic forms without

ni are added to certain Verbs (active or neuter) without conferring a definite transitive force on them, *'eli* to dig, *nia 'elia si 'ano* he dug the ground, *nia 'elifai kokoro* he dug deep; *oli* to return, come back, *olita'i* v.i. to return.

In Sa'a, Ulawa, Wango, there is a separation of the Syllabic Suffix *ta'i* (used with *ni* added) from the Verb; Wango *a nonia beia ai ta'e* huraa *wou i haka* ta'inia *i one* he asked him to thrust out the ship from the land; Sa'a *wai e* mapipi *ohe oto* ta'inic *kolune makana* whether the waters had receded from the surface of the land; Ulawa *ani* noto *nuuna* te'inilemiu in refraining yourselves. This Suffix *ta'i* thus used may be paralleled by the use of the separable Suffix *vag* in Mota, "Mel. Lang.," p. 281.

The Noun Suffix n*a* may be attached in Sa'a and Ulawa to the Syllabic Suffix, *usuneine* commandment. The Noun Suffix n*a* is not attached to the Consonantal Suffix, but always to the Verb itself, but where a Verb is made up of a Noun and a Verb used with a Consonantal Suffix the Noun Suffix is added to the Verb so formed, *sae unuhi* to grudge, *sae unuhine* a grudging spirit.

(9) *Verbal Suffixes in Melanesian New Guinea.*

The following examples have been collected from Mr. Ray's work, "Expedition to Torres Straits," Vol. iii., p. 458:—

Roro.

The Verb takes a Suffix *na* or *ni* when directly governing the Pronoun; *ita* to see, *ne itana'u* he ses me; *na itanio* I see *you*, *hau na itana* men I see them.

Mekeo.

Mikinalc malele ipa-lononi-i aui missionary teaches the men to read (*pa-lono* make hear).

Motu

Haga to gape, *hagai* to open the mouth, *laqa* to graze, *laquhi* to strike something in falling; *boi* to call, *boili* to call a person; *kanudi* to spit (Samoan *anu*); *rani* to be overtaken by daylight (Pol. *ra* day); *di* and *ni* are not quoted as Suffixes by Mr. Ray. *Noho* to stay, *nohori* to delay, *gugu* to clasp, *guguba* to hold tight, *gugubai* to squeeze; *gege* to surround, *hegegedai* to go round; *lao* to go, *laohai* to go away with; *heagi* to boast, *heagilai* to praise; *vasi* to go near, *vasilai*, to take near; *abi* to take, *abilai* to take with; *matamata* new, *matamatai* to begin; *qaqa* a lump, *heqaqanai* to stumble; *dina* sun, day, *hedinarai* to confess.

Keapara and Hula.

Ila to speak, *ilagi* to speak to; *ao* to go, *aogai* to go with; *gegelagi* to surround (c.f. Motu *gege* to surround); *veamai* to bring, *veamaiagi* to come with; *borogiagi* to be a substitute for (c.f. Motu *boloa* a substitute, *hebolo* to be a substitute).

Suau.

Saha what? *u sahaigu* what have you to do with me? *atai* to know about, *guiau vasana i ataiei* the chief his word he knew it.

Kiriwina.

I saopa he tell lies, *i saopaki* he deceives, *i saopakaigu* he deceives me; *iliki* he goes to him.

Wedau.

Bawana a bundle, *bawai* to carry in a bundle; *gudu* door, *gudui* to close a door; *riwa* to say, *riwei* to tell; *vipeuni* to drop something (*vi* Causative *peu* to drop); *qa* to be finished, *viqai* to finish; *kiala* to sit, *kialei* to sit on something; *galo* to be in soak, *vigaloi* to soak something; *viai* to be clean, *u ta viaini-u* you (may) clean me.

Tavara.

koekoeama false, *koeame-hi* deceive them; *kuku* near, *lei-kukui* to make near; *hanapu* wise, *hanapugeni* to know.

Mukawa.

waba a name, *wabei* to name; *botu* to come, *botuvi* to bring; *tomatoma* drinking, *tomani* to drink something; *nagari-si* fear them, *kega ke nagara* do not fear; *wona* to say, *woni* to tell; *gaigaire* clean, *gaireni* to cleanse.

Remarks.—The above instances show the addition of the Verbal Suffix to Verbs, Nouns, and Adjectives, but no instance is given of the Suffix added to an Adverb. In Suau the Suffix is attached to *saha* what? but as shown by Dr. Codrington ("Mel. Lang.," p. 134), this Pronoun common to the Oceanic Languages *saha*, *sa*, *sava*, *taha*, is a Noun.

(10) *Other Suffixes to Verbs.*

Ta; Motu *mahuta* to sleep (Sa'a *ma'ahu*); Samoan *faufili* a cord to fasten a bundle, *faufilita* to come back empty using the *faufili* to beat off the flies; *mafuta* to be aroused from sleep; *'apata* to clap

the wings (Sa'a *apa* wing); Maori *kapekapeta* to flutter (Sa'a *hiuhiu kape* to flutter, a wagtail, c.f. Maori *kapakapa*, Mota *lapalapa* to flutter).

Possibly *ta* in the above instances is the same as *ta* the adjectival Suffix.

Na; Sa'a *loloku* to be bent, *lokuna* v.t. to bend; *qao* to do, *qaona* to appoint; *duu* to move v.i. *duune* to move a thing up; *ata* to move, *atana* to move a thing slightly; Motu *pisili* spray, *pipisina* to splash (Samoan *pisi* to splash, Sa'a *qisi* v.i. to splash, *qisili* v.t.); Mota *tiana* to be pregnant, *tia* belly.

Sa; Samoan anusa to spit (Mota *anu-s* spittle); *po* night, *ponisa* to be dark; *ranu* water, *ranusa* to bale water (see "Mel. Lang.," p. 181.) Mota m*aru* to sink, subside, m*arusa* to subside.

Va; Samoan *musumusu* to whisper, *musuva* to whisper together.

La; Samoan *ua* rain, *uala* to be rainy with sunshine; Sa'a *'apala* to carry in the arms, *'apa'apa* wing, shoulder; Mota *sapan* Samoan *sapasapai* to carry in the arms, probably show *sapa* with a Verbal Suffix. Dr. Codrington connects *sapan* with *panei* hand. Mota *wanara* branch, may show *ra* as a Verbal Suffix, *wana* to open the mouth.

N*a;* Samoan *to'ana* to settle down, to frequent, *to'a* to settle; Maori *kapu* to close the hand, *kapuna* to take up with both hands. In these two instances the Suffix n*a* is probably the Noun Suffix.

Rana; Maori *pu* a heap, *purana* to heap up; *hua* to raise with a lever, *huarana* to transplant; *kapu* to close the hand, *kapurana* to take up by handfuls (Marquesas *kapu* hand). This termination *rana* is probably the gerundival Suffix.

In some of the Oceanic languages *a* is used as a Verbal Suffix:—Samoan *tane* man, *tanea* having to do with men; *lele* to fly, *lelea* to be carried off by the wind; *sili* exceedingly, *silia* to let pass; *lai* the westerly wind, *laia* to be blighted by the westerly wind; Motu *lokua* to be folded (Sa'a *loloku* bent). This termination *a* is probably the same as the adjectival Suffix *a* (see below under Table IV.), Niue *niu* coconut, *niue* possessing coconuts; Sa'a *niuniu'e* tasting of coconuts. The Suffix *la* in Samoan *uala* is also probably the same as the adjectival Suffix *la*, Sa'a *'usu* dog, *'usule* possessing dogs.

TABLE II.

Noun Suffixes.

Dr. Codrington, in "Melanesian Languages," give no Table of Noun Suffixes. The Melanesian examples in this Table have been

compiled from the various grammars in Dr. Codrington's book; the Sa'a and Ulawa lists have been amplified; the Malagasy examples are from Richardson's "Malagasy Grammar"; the Melanesian New Guinea have been copied from "Torres Straits Expedition," Vol. iii.

	Abstract Nouns.		Independent Nouns.	
	(1) with *n*	(2) without *n*	(1) with *n*	(2) without *n*
		(a) Loyalty Islands.		
Nengone			*ne*	
		(b) New Hebrides.		
Anaiteum			*n*	
Nguna	*ana*		*na*	
Sesake	*na*			
Epi	*ena*			
Fate	*ana, ena, an, en*			
Santo		*a*		
Araga	*ana*			
Oba	*ana*			*i*
Maewo	*ana, na*	*a*		*i, iu, ui, gi*
		(c) Banks' Islands.		
Merlav	*ne*	*a, ia, va*		*i, gi*
Lakona		*e, g*	*n*	*gi*
Gog		*g, i,*	*n*	
Vanua Lava		*a, e, ea, g, r*		*gi*
Mota		*a, ia, ga, ra, va*		*i, iu, ui, ei*
		(ta, i, s)		
Motalava		*e, r, g, v*	*n, ne*	*ge*
Torres' Islands		*i, r, ve*		
		(d) Fiji.		
			na	
		(e) Maori.		
	(*α*) n*a*			
	(*β*) Gerundives, n*a*, *ana, kana, rana, tana*	*a, ha, i*	*na*	
		(f) Samoan.		
	(*α*) n*a*			
	(*β*) Gerundives, n*a*, *ana, lana, mana tana, sana*	*a, laa, ta*	*ne*	

	Abstract Nouns. (1) with *n*	Abstract Nouns. (2) without *n*	Independent Nouns. (1) with *n*	Independent Nouns. (2) without *n*
		(g) Malagasy.		
	ana, na	*tra, ka*	*na*	-
		(h) Malay.		
	n, an	*k, t, r, s*	*na*	-
		(i) Tongan.		
	(For Gerundives see Samoan)	*a*	*na*	-
		(j) Rotuma.		
	na, in, un	-	-	-
		(k) Solomon Islands.		
Fagani	*na*	*fa*	-	-
Wango	*na*	*a, ha*	*na*	-
Ulawa	(α) *na*	*ha, 'a, ta*	*na*	-
	-	(β) *la-, le-, ta-*	-	-
Sa'a	(α) *na*	*a, ha, la, ta,*	*na*	-
	-	(β) *la-, le-, ta-*	-	-
Lau	(?) *na*	*a, fa, la, ta*	*na*	-
Florida	-	*a*	*na, ni*	-
Bugotu	-	*a*	*na, ni*	-
Savo	-	-	-	*ga*
		(l) Melanesian New Guinea.		
Motu	*na*	-	*na*	*a*
Panaieti	*na*	-	*n*	-
Wedau	*na*	*ra, va*	*na*	*i*
Dobu	-	-	*na*	-

NOTES, ETC., ON TABLE II.

"In the Melanesian languages there are two classes of Verbal Substantives, those which may be called Gerundives, which are rather more Verbal than Nominal, and others which are more properly Abstract Nouns. The first class are such words as 'thinking,' the second such words as 'thought.' Melanesian languages do not generally appear to have both kinds of Verbal Substantives together. Polynesian languages do not appear to have the second class at all." ("Mel. Lang.," p. 138.) Dr. Codrington instances

only Fagani and Merlav as having both classes, but Maewo will be seen to possess both, and three Solomon Island languages in the Table besides Fagani have both, and Maori and Samoan have both; c.f. *infra*. Wedau also has both forms. The first class of these Noun Suffixes, the gerundival, has *n* as a constant letter, in the second class *n* does not appear.

In the Melanesian languages the form of the Gerundive is not always the same, as the Polynesian has the termination *nga* (*na*). *Mate* is commonly "to die," but *matea* in Florida is "dying." *Galea* in Mota may mean either deceit or being deceived, *na galeana* what deceived him. In Fiji *mate* without change is "to die," and "death" as it is in Maori. But when the Maori uses *hemo* for "to die," "death" is *hemona* dying. ("Mel. Lang.," p. 138.)

The Suffixes *la*, *le*, *ta*, *ha*, are used in Sa'a and Ulawa with the Personal Pronoun always suffixed to form Gerundives; with neuter Verbs *ni* or *i* is always added; *horo* to kill, *horo'i* to kill anyone, *horo'ilana* his being killed. The sense of the Gerundive in Ulawa and Sa'a is either Active or Passive, *tohulana* the chopping of it, its being chopped; Ulawa *ha'auritaku* my being saved, *a ha'auritaku* my saviour. In Ulawa n*a* with the suffixed Pronoun may be used as a Gerundive; *lae* to go, *laena* a going, *laenana* his going. With the Maori Gerundive the action may be either Active or Passive.

In Florida Verbal Substantives are formed by suffixing *a* to Active Verbs, and the sense of these, which may be called Gerundives, is often Passive. *Bosa* to speak is also a Noun, and *bosagu* is my speaking; but *bosaagu* is my being spoken to. In Ysabel it is the same, *gotigotihi* to break in pieces, *na gotigotihiadia* their being broken in pieces. ("Mel. Lang.," p. 524, 139.)

The Ulawa word *wala'ana* speech, needs a little explanation. Dr. Codrington ("Mel. Lang.," p. 138) gives *wala'ana* as an instance of *ana* used as a Noun Suffix, but no other such instance occurs in Ulawa, and the Verb is *wala* or *wala'a* to speak; *ha'i wala* a word, *walana* his word, *kira ahuni wala* they took counsel together, *wala odoodo* to repudiate in speech, *'o si'e walawala'a* do not speak. A form *walani* also occurs meaning to effect a magical charm by means of words. The second form of the Verb, *wala'a*, may possibly be made up of *wala*, and *'a* the adjectival Suffix, and accordingly *wala'a* would mean dealing in words, wordy. This Suffix *'a* is added to certain Verbs in Ulawa and Sa'a to form Nouns; *usi* to barter, *usi'e* market; *kalite'i* to encircle, *ro kalite'i'a* double strands. With *wala'ana* may be compared *roro'ana* debt,

which is formed from the Verb *roro'a* to be liable, and this again is formed from *roro* to tie tightly and *'a* the adjectival Suffix. A Noun *walana* appears in Sa'a in compounds, *mu tale'i sulu walana* mere verbose repetitions.

In Ulawa and Sa'a certain words show the Noun Suffixes *ta*, *ha*, but are used only with the suffixed Pronoun or with the Possessive attached; *hono* to close, *honotana* against, to meet, him; *walahada* their word; *i lado'ihaana* in a straight line with; in the last example *'i* the Verbal Suffix has been added; *painahaana* its bigness. This points to *ta* and *ha* having a gerundival force in these words. In *na'unekume* a seat (*naku* to sit), *me* (*ma*) appears to be a Noun Suffix.

In both Samoan and Maori Noun Suffixes of the second class are found; Samoan *fua* fruit, *fuata* crop, as well as *fuana; tau* to fight, *taua* war, *tauna* a fighting; *taula* an anchor, *tau* to anchor; *tee* to prop up, *teela* a boom; *mafuta* dwelling together, may show the Suffix *ta* (c.f. Motu *mahuta* to sleep, Sa'a *ma'ahu*), *nofo* to sit, *nofoa* a seat.

Maori: *puaha* the mouth of a river, *puaki* to come forth (Samoan *pua* the mouth of a fish trap); *kareha* the day after to-morrow, the day before yesterday, may possibly be composed of *kare* and *ha* (c.f. Mota *risa*, Florida *valiha*, Samoan *alivu* long ago, Ulawa *wali* long ago, *walita* day after to-morrow); *tatau* to assault, *taua* war party; *ahu* to heap up, *ahua* form, appearance (for *ahu* as "to tend," "to heap up," "to be mature," c.f. Sa'a *ahu* to be perfect, *ahu'i* to surround, protect, *ahui ola* a parcel); *kagu* to put on, surface, garment, *kahua* form, appearance; *kafui* herd, Samoan *lafu* herd.

Mota appears to have other Noun Suffixes besides those given by Dr. Codrington; *lumuta* moss. Sa'a *lumu* and *lumute; anus* spittle, Motu *kanudi*, Samoan *anu; puasa* lizard, *vua* crocodile, Sa'a *huasa* crocodile, Samoan *puaa* animal; *kurut* dog, Sa'a *'usu*, Maori *kuri*, Malagasy *alika*.

It is unnecessary to give here instances of the use of the Noun Suffixes in Melanesia, they may all be found in "Melanesian Languages."

Noun Suffixes in Melanesian New Guinea.

Motu,

doko to finish, *dokona* the end; *ranu* water, *ranuna* juice; *bero* to wound, *berona* a wound.

Panaieti,

rohu to condemn, *rohuna* condemnation.

Wedau,

am to eat, *amna* the eating; *bawai* to carry in a bundle, *bawana* a bundle. In Wedau *na* is added *to* the root of a transitive Verb, i.e. to the Verb without the transitive ending; *babani* to talk, *babana* the subject discussed. Noun endings of the second class without *n* are seen in Wedau, *tigura* a thorn, *tiguri* to pick out with a thorn; *utuva* a flood, *utuvi* to water; *iuwa* fruit, *uwei* to bear fruit. ("Expedition to Torres Straits," Vol. iii. p. 440.)

Noun Suffixes in Malagasy.

Vono to kill, *vonoana* murder; *ravina* leaf (Mota *naui*, Polynesian *rau*, Malay *daun;*) *hatsara* good, *hatsarana* goodness; *havitra* fish hook (Malay *kawit*, New Guinea *gahu*, Mota *gau*); *loaka* aperture (Polynesian *lua*, *rua* hole), *bono* to cover, *bonoka* a covering.

Noun Suffixes in Malay.

Daun a leaf (Motlav *ron*, Fiji *drau*, Maori *rau*); *ujan* rain (Lau *usa*, Maori *ua*); *ikan* a fish (Pol. ika); *kumis* mustache (Mota *wunui* Maori *kumikumi*); *arus* current (Mota *aru*); *mataku* to fear, *pankutan* fear; *tidor* to sleep, *partidoran* sleep; *kata* to speak, *parkataan* speech; *lumut* moss (Maori *lumulumu*); *laut* sea shore (Mota *lau*); *kawit* fish hook; *sinar* ray of light (Melanesian *sina* to shine).

Remarks.—The terminations shown above in Malagasy and Malay show definitely the connection between them and the other Oceanic languages given in the Table, but it can hardly be said that these two languages use the Noun Suffixes as freely as the Melanesian languages use both classes of the Suffix, or the Polynesian the first class.

Tongan appears to have a form in *a; huhu* breast, *huhua* milk.

The Gerundives in Maori.

The Verbal Substantives in Maori denote the taking place of an action, the place of the action, the time of its taking place. The action may be either Passive or Active. ("Mel. Lang.," p. 138.) However, n*a* is suffixed in Maori to form Abstract Nouns, just as it is in Melanesia; *kawe* to carry, *kawena* a burden (c.f. Sa'a *tola* to carry, *tolana* a burden); *ako* to learn, *akona* a learner; *keokeo* peaked, *keokeona* a peak; *rahi* big, *rahina* bigness (Sa'a *paine* big, *pianana* size); *koi* sharp, *koina* point, edge; *tika*

straight, *tikana* rule, plan (Sa'a *odo* straight, *odoodona* straightness), *rite* like, *ritena* likeness. In the same way *ana* and *tana* form Noun Substantives; *noho* to sit, *nohoana* a seat; *kawiti* to taper, *kawititana* the wrist; *hua* to bear fruit, *huhuatana* excellence; also imported words *kinitana* dominion; *kawenatana* government; *kapu*, to close the hand, makes both *kapuna* palm of the hand, and *kapurana* handful, and each of these words serves either as a Noun or a Verb. Still it is plain that the suffixing of *na* conveys even in these examples in Maori more of the idea of a Gerundive than of an ordinary Abstract Noun.

The Gerundives in Maori are composed of the Noun Suffix *na* by itself, or of the Suffix *ana*, either by itself or with *h*, *k*, *m*, *r*, *t*, ἐφελκυστικόν, where the Consonant in each case is the same as the Consonant of the Verbal Suffix. When the Passive is formed by adding *ia* to the root Verb then *ana* is suffixed to the root Verb to form the Gerundive; *ko* to plant, *koia* planted, *koana* sowing time. The Suffix *ana* itself does not occur as a Noun Suffix anywhere, but *ana* occurs frequently, and there is no radical difference in form between *ana* and *ana*, or between *na* and *na*, since n is only nasalized *n*.

It seems to be evident that the gerundival forms with the Consonant ἐφελκυστικόν are composed of two parts, and since the initial Consonant is the same as the Consonant of the Verbal Suffix it would seem that the construction of these particular forms of the Gerundive is either this Consonant and *ana* (in which case the Consonant alone would be considered to be the real Verbal Suffix), or the Verbal Suffix and *na*, the *i* of the Verbal Suffix being changed to *a* for the sake of euphony, i.e., *tana* for *tina*, etc. Thus in Sa'a *e* gives place to *a* before *na* and *ta* for the sake of euphony; *nike* mother, *nikana* his mother; *hune* to anchor, *hunata* an anchor. If it be considered that *ana* is added to the Consonant of the Verbal Suffix in order to form the Gerundive, then it might be considered that *ana* itself is probably a compound Noun Suffix, being made up of *a* and *na*, which both appear as Noun Suffixes. Ulawa furnishes instances of the use of compound Noun Suffixes; *alida* to travel by sea, *alidana* also *alidanaha* a sea journey; *kae* to deceive, *kaena* also *kaenaha* deceit; *raqa* to deceive, *raqatana*, guile.

Gerundives in Samoan.

In Samoan *na* is used as a Noun Suffix forming Abstract Nouns to a greater extent than in Maori; *tuli* to drive, *tulina* driving;

malolo to rest, *malolona* a resting place (Sa'a *mamalo* to rest, *mamalona* a rest, *mamaloha* a resting place); *tau* to fight, *tauna* a fight, *feana'i* to correspond, *feana'ina* a relationship; *poloa'i* to command, *poloa'ina* a commandment; *ulu* to make double, *uluna* a pair; *tanu* to bury, *tanuna* a burial. The other gerundival Suffixes are also used to form Abstract Nouns; *luluu* to fill the hand, *luutana* a handful; *anu* to spit, *anusana* spittle; *inu* to drink, *inumana* a drink; *ola* to save, *olaana* life time, *olatana* a means of deliverance; *lele* to fly, *lelea* to be driven away by wind, *leleana* a party driven off by a strong wind; *tau* to anchor, *taulana* a harbour. The second class of Noun Suffixes in Melanesia furnishes examples of such secondary usages; *la*, *le*, *ta*, *ha*, in Sa'a and Ulawa when used with the suffixed Pronoun or the Possessive have a more or less gerundival force (see above); *saanau* a young man, *saanauheku* my youth; *tono* to drink, *tonohana a Kalita'alu* the drinking (place) of *Kalita'alu*. In these two languages when it is desired to form Abstract Nouns from Verbs to which these gerundival endings may be added the Noun Suffix n*a* is used and not one of these gerundival Suffixes; thus *tono* to drink, *tonona* drinking, and not *tonoha*.

Remarks.—It may be concluded then from the Samoan use that the gerundival ending n*a* in Samoan and in Maori is the same as the n*a* which appears in Melanesia as a Noun Suffix. And since in Samoan the Gerundives (with the exception of n*a* and *ana*), employ the Consonant of the Verbal Suffix, whether that Suffix is attached by itself to the Verb, or only appears with the addition of *a* as forming the Passive of the Verb (*takahi* to trample, *takahana* the trampling; *huaki* to open, rush on, *huakana* the rushing on; n*aromia* to be destroyed, n*aromana* the destroying) the conclusion may therefore be drawn that the Gerundive in Samoan as well as in Maori is compounded of Verbal Suffix and Noun Suffix or Suffixes, and that either the Vowel of the Verbal Suffix is changed to *a* for euphonic reasons, or that with the elision of the Vowel *i* of the Verbal Suffix the Gerundive is made up of the Consonant of the Suffix, and *ana* a variant of n*a* and possibly itself a compound of the two Noun Suffixes *a* and n*a*, the two classes of the Noun Suffix thus combining to form the special gerundival Suffix.

Independent Nouns.

"Independent Nouns are formed by adding the terminations *i* or *gi*, *iu* or *ui*, or *n* to the stem word—there is only one class of words which receives this generalising termination—Nouns

which signify parts of a whole, members of a body; things which can stand in a certain relation to some inclusive whole." ("Mel. Lang.," p. 141.) Nouns with these terminations are found in the vocabularies of the Banks' Islands' and New Hebrides' languages for "belly," "body," "bone," "child," "ear," "egg," "face."

Dr. Codrington states that these terminations are not found in the Polynesian languages, or in Fiji. This statement is undoubtedly correct in regard to the greater number of the Nouns or subdivisions of the class of Nouns which he instances, but it will be found that a great number of the Oceanic languages which do not otherwise show any trace of these terminations, yet have terminations in *n* or *na* in Nouns signifying membership of a body, or relationship, e.g., father, mother, brother (but not including child, husband, wife).

It is almost impossible for one accustomed to the practice of the Melanesian languages to believe that the Maori word *taina* brother does not really mean "his brother," and so also with *tupuna* ancestor, which means in Mota "his ancestor," but comparison with Nengone *tenene* child, where *tene* is the stem, and with Anaiteum *netgan* belly, *nohun* body, *naklin* egg, Motlav *nten* child, *tlen* egg, shows that the final *na* in *taina* is a Noun termination, and not the Suffixed Pronoun. In the Banks' and New Hebrides' languages this Noun termination is dropped when the Pronoun is suffixed, Mota *natui* son, *natuna* his son, Nengone *tenene* child, *tenego* my child; but since the Polynesian languages do not suffix the Pronoun to the Noun, the *na* or *ne* of the Independent Noun form remains constant. Ordinarily in Ulawa and Sa'a the words expressing relationship have no particular termination as such, but when certain Prefixes are used to mark reciprocity of relationship or of kinship, *ma*, ma, *ha'i*, *he'i*, the Noun to which they are affixed always has the termination *na* or *ne; nike* wife, *ro ha'i nikana* a man's wife and child; *mu he'i malahune* friends; *uweli* (Vocative only) a boy's uncle, a man's nephew, (sister's child) *ro ma uweline* uncle and nephew; *ro* ma *'asine* brothers, *mu* ma *'asine* brethren; *ro ma hunaona* father- and son-in-law; *ro ha'i ma'amana* father and son. There seems to be no reason to doubt that the termination *na* seen in these Sa'a words is identical with the *na* seen as a termination of the words expressing relationship in other Oceanic languages. In Sa'a and Ulawa all the words expressing kinship (and the word for "friend" also), except those for "wife," "husband," "father" (when in the Vocative), "child," are never used

without a suffixed Pronoun, i.e., there is no way of saying "brother," "sister," "friend," etc., without saying "my brother," etc. This peculiarity of speech seems to suggest that originally certain Nouns expressing kinship or relationship had a definite termination as such in these two languages as they have in Polynesia; and the refusal of the two peoples to use these words except with a suffixed Pronoun may mark a consciousness of the loss of the termination.

In Mota "a brother," "the brother," is rendered *o tasiu*, in Maori *te teina*, in Sa'a *a ma 'asine*, in Ulawa *a 'ulaka'elu* (*ka'elu* meaning "our"). This termination *na* is seen extensively in the Oceanic languages in words denoting relationship:—Maori *tupuna* ancestor (Mota *tupui*); *teina* younger brother (Mota *tasiu*); *tuakana* elder brother; Samoan *teine* girl; Niue *hoana* friend (Maori *hoa*, Mota *soai*); Fiji *tinana*, Motu *sinana*, Samoan *tina*, Malay *inana*, mother; Fiji *tamana* father (Mota *tamana* his father), *tukana* grandfather; *lomana* heart, may be an instance of *na* as a Suffix; *suina* bone certainly shows *na* as a Suffix (Mota *suriu*, Sa'a *su'isuli*).

Melanesian New Guinea shows *i*, *a*, *na* as Suffixes forming Independent Nouns. Wedau; *natui* son; *amana* father. Dobu; *nimana* hand; *luluna* bone. Panaieti; *matan* eye; *niman* hand; *maninin* face. Motu; *tamana* father; *tadina* brother; *kakana* elder brother; *turia* bone (Oceanic *suli*); the word for "hand" in Malagasy *tanana* seems to show *na* as a Suffix of this nature; c.f. also Malay *tanan* hand (Polynesian *tano* to touch). In Sa'a, Ulawa, San Cristoval, Samoa, *na* is added to Cardinals to form Ordinals, *ni* is thus used in Florada, and *iu*, *i*, in Mota, and the word so formed is a Noun; hence it is probable that these endings *na*, *ni*, *iu*, *i*, are identical with the terminations of the Independent Nouns.

TABLE III.

Passive Suffixes.

	(1) with *n*	(2) without *n*
(a) Florida		*a* (?)
(b) Bugotu		*a* (?)
(c) Fiji		*i* (?)
(d) Maori	*na, ina, rina, whina*	*a, ia, hia, kia, mia, nia, ria, tia*
(e) Samoan	*na, ina, a'ina*	*a, ia, fia, lia, mia, nia, sia, tia*
(f) Gilbert Is.	*kina*	
(g) Malagasy	*na, ana, ena, ina*	

TABLE IV.

Adjectival Suffixes.

For the foundation of this Table see "Mel. Lang," p. 167, Torres Straits' Expedition, Vol. III., p. 453.

(a) New Hebrides.

	(1) with *n*	(2) without *n*
Sesake		*a*
Nguna		*ga*
Araga		*ga*
Oba		*ga, gi*
Maewo		*ga, gi*

(b) Banks' Islands.

	(1) with *n*	(2) without *n*
Lakona		*g*
Vanua Lava		*g, r*
Mota	*n, na*	*a, ga, ra, sa, ta*
Motalava		*g*
Volow		*g*
Ureparapara		*a, ra*

(c) Fiji.

	(1) with *n*	(2) without *n*
	-	*a, li, ta*

(d) Samoa.

	(1) with *n*	(2) without *n*
		a, la, sa

(e) Tongan.

	(1) with *n*	(2) without *n*
		a

(f) Malagasy.

	(1) with *n*	(2) without *n*
	na, ana, ena, ina	-

(g) Solomon Islands.

	(1) with *n*	(2) without *n*
Ulawa		*'a, 'ala, la, ta'a*
Sa'a		*'a, 'a'a, 'ala, la, le, ta'a*
Lau		*a, laa*
Fagani		*ga*
Wango		*'a*
Vaturanga		*ha*
Florida		*ga*
Savo		*sua*
Duke of York	*ina*	-
New Britain	*ina*	-
Gilbert Islands	*ina*	-

(h) Melanesian New Guinea. (See "Torres Straits' Expedition." Vol. III., p. 454).

	(1) With *n*.	(2) Without *n*.
Motu	-	*ka, ga, ta, va, a*
Kabadi	-	*va*
Wedau	-	*ra*
Dobu	*na, ina*	-

(i) Malay.

	an	-

NOTES, ETC., ON TABLES III. AND IV.

The two instances of Passives in Melanesia in the languages of Florida and Bugotu have been referred to above under Table ii., Noun Suffixes. Dr. Codrington states that the *a* in these two instances being attached to the Verb conveys a sense which is Passive. It will be noticed in these two instances that the Suffix *a* which is used could not be the Suffixed Pronoun since the Pronoun is added to it, and the adding of the Pronoun proves that the word so formed is a Noun, since the Pronouns *gu*, *mu*, *na*, etc., are attached only to Nouns, and in consequence this *a* must be a Noun Suffix. Its use then in Florida and Bugotu may be compared with the use of the Noun Suffixes *la*, *ta* in Sa'a and Ulawa, which also are used with a gerundival force, and we should thus conclude that there is no real example of Passive Suffixes in Melanesia.

Dr. Codrington ("Mel. Lang.," p. 192), suggests that the Maori Passive may have arisen from an impersonal use of the Verb after the style of the following sentence in Mota; *me taur veta o ima* built already the house, the house is built. There is no passive in Melanesia as such and the nearest approach to it is in such impersonal uses of the Verb. Mr. Ray, "Common Origin of the Oceanic Languages," considers that the Passive in Polynesian is built up of the Verbal Suffix and *a*, and he considers this *a* to be the Suffixed Pronoun, but he gives no reason why the Pronoun should be suffixed in the third Person Singular only, nor why this special Melanesian characteristic of suffixing the Pronoun should thus occur in Polynesia. As he says words like *punitia* and *tanisia* in Samoan have a decidedly Melanesian look, but in no Polynesian language is the Personal Pronoun suffixed to the Verb, and this fact alone would seem to vitiate Mr. Ray's theory as to the nature of the termination *a* of the Polynesian Passive. Dr. Codrington is probably correct in his theory of the Passive arising from an

impersonal use of the Verb, but he propounds no theory to account for the endings of these Passive Suffixes, though he calls attention to the similarity between the first part of them and the Verbal Suffixes, and Mr. Ray's theory fails to account for the Passive Suffixes which contain *n*.

It will be noticed in Table iv. that the adjectival Suffixes in Malagasy are the same as the Passive Suffixes. Richardson ("Malagasy Grammar") says that "the place of English Adjectives in *able*, *ible*, is supplied in Malagasy by Passive Verbs preceded by *azo*, e.g., *azo hanina* eatable, *tsy azo resena* invincible." In the Dictionary, *hanina* appears as a Noun, but the presence of *gana*, *'ani*, in Oceanic languages, meaning "to eat," suggests that *hanina* is made up of *hani* v. and *na* Suffix, and *resena* is an Adjective formed from *rese* v. The use of the Passives in Malagasy *na*, *ana*, *ena*, *ina*, is plain enough, but while Dr. Codrington says that there is no sign of special forms in Malagasy for adjectival endings Richardson in his "Grammar" in a Table of Adjectives says that they are "formed from the root of the word with the affix *ina*, *ena*, *ana*," and he instances *nofo* flesh, *nofosana* fleshy. To this may be added *vory* froth, *vorena* frothy; *vaoka* whiskers, *vaohina* whiskered; *somotra* beard, *somorina* bearded; *olitra* a worm, *olerina* wormy; *ozatra* muscle, *ozatina* muscular; *volo* hair, *voloina* hairy. Many of the so-called Adjectives in Malagasy are evidently Neuter Verbs, while others are Participles, e.g. *fotsiana* whitened (*fotsy* white), is evidently a Participle. From the above example the connection seems established between the Passive and the adjectival (or participial) terminations in Malagasy.

Polynesia has no adjectival endings of the first class containing *n*, but Micronesia has Gilbert Islands *mama* moonlight, *mamaina* white (Mota *vula* (1) moon, (2) white), and Melanesia shows four; Mota *wawana* wide, oba *wawa* open sea (Sa'a *matawa* open sea, Malag, fafana, M.L. p. 189, c.f. Malag. *masina* salt, Figi *masima*); Mota *malea* tasteless, *malean* brackish, Duke of York *ina; ruma* house, *rumaina* containing houses; Dobu *na; werabana* witch, *werabanina* witch-like; *barau* sorcerer, *barabarauna* sorcerer-like; *bila* to rot, *bilabilina* rotten; *muta* to mould, *mutamutana* mouldy; *'edagi* to laugh, *'eda'edagina* having the quality of laughter; *siwa* to pour out, *siwasiwana* poured out; *'etune* to send, *'etu'etunena* the sent. New Britain *ina; kaban* lime, *kabanina white*. Malay shows *an* used in the same way; *pileh* to choose, *pilehkan* v.t. *pilehan* chosen; *bantah* to con-

tradict, *bantahan* quarrelsome; *durian* a thorny fruit, *duri* a thorn, *rambutan* a hairy fruit, *rambut* hair, probably shown *an* as an adjectival ending. In Tagalog *an* appears as an adjectival Suffix equivalent to *-able* in English, *lapit* idea of approaching, *di malapitan* unapproachable.

From the evidence of the endings in Malagasy and from the use of *an* in Malay and *na* in Melanesia as adjectival endings it may safely be concluded that the termination *na* of the Passive Suffixes in Polynesia is identical with the termination *na* of the adjectival Suffixes seen above.

The use of the adjectival Suffix *a* in Samoan and Melanesian justifies the conclusion that the Passive Suffix *a* is the same as the adjectival Suffix *a*. Samoan shows *a* and *sa* as adjectival Suffixes; *eleele* dirt, *eleelea* dirty; *naoa* also *naosa* stony; Tongan *maka* stone, *makaia* stony; Motu *lokua* folded (Sa'a *loloku* to be bent). The Suffix *a* is used with an adjectival force in the following Samoan words: *Tane* man, *tanea* having to do with men; full of men; *lele* to fly, *lelea* to be carried off by the wind; *lai* the westerly wind, *laia* to be blighted by the westerly wind. In Sa'a and Ulawa the adjectival Suffix when added to Verbs conveys a sense which might really be said to be Passive; *rere* to sharpen by rubbing, *rere'a* sharpened, clean; *roro* to be tight, to incur a debt, *roro'a* to be at fault, to have incurred a debt; *ere* to coil, *ereere'a* also *ereerea'ile* (*a'i* Verbal Suffix) coiled. The explanation of the Ulawa word *wala'ana*, *wala'a* to speak (see above, under Noun Suffixes) may possibly be found in the addition of *'a*, the adjectival Suffix to the Verb *wala*.

There remains yet the provision of a theory to account for the initial portion of the Passive Suffixes, *hi*, *mi*, etc., of the second class, and *i*, *ri*, *whi*, *a'i*, of the first class. It will be noticed that the Consonant and first Vowel of the Passive Suffixes of the second class, and the initial vowel or Consonant with Vowel (excluding the form *na*) of the first class are the same as the initial Consonants and Vowels of the Verbal Suffixes, and since the use of Passives in the Polynesian languages has very probably arisen, as Dr. Codrington suggests, from an impersonal use of the Verb as seen in Melanesia, we seem to be justified in concluding that the Passive Suffixes are made up of the Verbal Suffixes with the addition of the adjectival Suffixes conveying a participial force.

The use of the Transitive Suffixes in the formation of the Passive Suffixes would seem to be accounted for by what Mr. Ray says

in "Common Origin of the Oceanic Languages," "The identity of passive and transitive is strengthened by the fact that the Polynesian passive is used when the *action* is emphatic rather than the agent, and hence is more frequently used in the case of transitive verbs than the active form." This laying stress upon the *action* is seen in the Samoan Passive Suffix *a'ina* which is said to denote intensity of action; *tuli* to drive, *tulia'ina* to drive on; *telea'i* to run quickly, *telea'ina* to hurry on. The same thing appears in the Gilbert Islands where the Passive Suffix *kina* denotes "a frequentative use"; *matai* to look at covetously, *mataiakina* to look at with longing for; *mutiakina* to regard.

It having been shown that Verbal Suffixes occur in Polynesian languages there is no difficulty in drawing the conclusion that since the Verbal Suffix definitely strengthens the action of the Verb (and having regard to the nature of the Passive as explained above by Mr. Ray), the *hi*, *mi*, etc., and the *i*, *ri*, *whi*, *a'i*, of the Passive endings are identical with the Verbal Suffixes, and that the *a*, *na*, of the endings conveys the passive, i.e., the adjectival, or participial, force.

No rule can be given as to whether the Suffixes with *n* are to be used for the formation of the Passive in any particular case, or those without *n*.

The Passive in Fijian.

Dr. Hazelwood says that the Passive in Fijian is formed by replacing the final *a* of the Verbal Suffix by *i*, or by adding *i* to the verb when no Verbal Suffix is ordinarily used, but this statement is questioned by Dr. Codrington in "Mel. Lang.," p. 191, on the authority of Dr. Fison, who says that "no Fijian would use Hazelwood's example." If Dr. Hazelwood's examples of words used showing a passive meaning, are correct, then they would seem to fall into line with such words in Maori as *hokai* spread out; *punui* close together; *whai* settled. These have been shown above (see Verbal Suffixes in Maori) to be Participles formed by the addition of Verbal Suffixes.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART II., 1914].

ART. XXII.—*Notes on the so-called Obsidian from Geelong and from Taradale, and on Australites.*

BY PROFESSOR ERNEST W. SKEATS, D.Sc., A.R.C.S., F.G.S.

[Read 10th December, 1914].

Introduction.

In the Records of the Geological Survey of Victoria, Vol. III., Part 3, 1914, pp. 322-326, recently published, Mr. E. J. Dunn, F.G.S., in a paper entitled "Further notes on Australites," quotes some old analyses of Mr. Cosmo Newbery of two specimens of "obsidian" from the Geelong district, of a "basalt" from near Kyneton, and of an australite from the Wimmera Plains. In addition a recent analysis of a so-called obsidian from Taradale is quoted, and the claim is made in the paper that these analyses show that acidic volcanic glass, similar in composition to that of australites exists in Victoria associated with the newer volcanic rocks.

Mr. Dunn's long and wide experience as a field geologist ensures that any paper of his dealing with problems of field geology will command confidence and respect from all geologists. He has had, however, no special experience in chemical and petrological questions, and the problems raised in his recent paper and on australites generally are to a large extent chemical and petrological. In consequence of this I feel that he has misunderstood the evidence and come to erroneous conclusions.

The object of this communication is to criticise some of the evidence stated in Mr. Dunn's paper and to show that the older rock analyses of the Geological Survey of Victoria, in common with many old rock analyses, are quite unreliable, that the rocks from Geelong, described as obsidian, are really tachylyte, that the rock from Taradale is not obsidian, but a volcanic glass of peculiar composition and belonging to the Intermediate division, that no rock of the nature of obsidian is known to occur among the newer volcanic rocks of Victoria, and that in consequence no support is lent to the hypothesis of the volcanic origin of australites by an appeal to the chemical composition of the newer volcanic rocks of this State.

The nature of obsidian.

During the last century the significance of many of the terms used by the older mineralogists and geologists has by a process of evolution undergone change and revision. The change has usually been from a vague and general definition to one of a more precise and limited character. The progressive changes in the meaning attached to the word obsidian illustrate this process.

A century ago, and even down to 60 or 70 years ago, the black compact glass called obsidian was believed to be definite in composition and to constitute a true mineral species.

Later it was shown to be a volcanic glass of variable composition, and then any volcanic glass was spoken of as obsidian. At a later date the glassy form of basalt was distinguished by the name of tachylyte, while the name of obsidian was reserved for volcanic glasses of acid to intermediate composition.

In recent years intermediate volcanic glasses have been distinguished either as trachyte-glass and andesite-glass, or as trachytic-obsidian and andesitic-obsidian, while the term obsidian, without qualification, has been by petrologists restricted to the acid volcanic glasses corresponding in chemical composition to the rhyolites and acid granites.

It is this modern definition as an acid volcanic glass which alone should be applied to obsidian, and it is in this sense that I, in common with other petrologists, understand the term.

The present-day definition implies an acid volcanic glass of about the following composition :—

$$\begin{array}{l} SiO_2 = 66\text{–}80\% \\ Al_2O_3 = 13\text{–}16\% \\ \left.\begin{array}{l} Fe_2O_3 \\ FeO \end{array}\right\} 2-3\% \\ \left.\begin{array}{l} CaO \\ MgO \end{array}\right\} 1-3\% \\ \left.\begin{array}{l} K_2O \\ Na_2O \end{array}\right\} 6-8\% \end{array}$$

Most obsidians have a silica percentage of over 70, and it should be noted not only that the iron oxides seldom exceed 3 per cent., but that the alkalies are commonly in notable excess over the alkaline earths.

The so-called obsidians from Geelong.

In the Notes on the Physical Geography, Geology and Mineralogy of Victoria, by A. R. Selwyn and G. H. F. Ulrich, published in the Intercolonial Exhibition Essays, 1866, p. 65, obsidian is stated to occur in a basalt quarry near Geelong in patches and irregular veins of an inch or more in thickness. Two analyses by Mr. Cosmo Newbery are quoted from this locality. The same statements and analyses are quoted in Selwyn's Descriptive Catalogue of the rock specimens and minerals in the National Museum, collected by the Geological Survey of Victoria, 1868, p. 80. The specimens are labelled Specimen 24 and 24a.

These are two of the analyses quoted by Mr. Dunn, and are as follow :—

	Geelong Specimen. Black to brown. Sp. Gr. 2.41. No. 24.	Geelong Specimen. Bluish grey. Sp. Gr. 2.36. No. 24a.
SiO_2	72.23	68.45
Al_2O_3	16.43	5.38
Fe_2O_3	2.28	7.21
CaO	3.17	8.11
MgO	2.12	1.03
MnO_2	—	0.50
TiO_2	—	0.30
Na_2O K_2O	4.65	7.36
Loss by ignition	0.13	—
	101.01	98.34

To anyone accustomed to rock analyses the above figures at once suggest inaccuracy, not only by the summation, but still more by the curious and unusual proportions of some of the oxides.

Mr. Dunn has overlooked the fact that as long ago as 1898 Mr. Walcott[1] in his paper on Obsidianites had examined these specimens, had called attention to the discrepancy between the published analyses and the appearances of the specimens and had detached a chip from specimen 24 and by chemical analysis obtained only 53.2 per cent. of silica. He pointed out that the appearance and silica percentage pointed to the material being tachylyte and not obsidian.

1 Proc. Roy. Soc. Victoria, vol. xi. (N.S.), 1898, p. 32.

By the courtesy of Professor Spencer I was enabled to make an examination of the two specimens, Nos. 24 and 24A. There are two specimens of No. 24. The smaller is partly scoriaceous, partly dense, and is a dark grey-green in colour.

The larger specimen is similar to the smaller, but shows a sporadic development of spherical scoriaceous areas constituting pseudo-spherulites. The rest of the material is a dense glass.

No. 24A is dense and mostly dark blue in colour. Some black spherulitic areas occur with cracks, filled with brown limonite.

Both 24 and 24A have all the appearances characteristic of tachylyte, as Mr. Walcott has previously described. I determined the specific gravity of the two pieces of No. 24 by Walker's balance. The small piece gave a value of 2.36.

The specific gravity is, of course, quite unreliable, as the specimen is very vesicular. The true specific gravity would be much higher.

The larger piece of 24 gave a value of 2.50.

This specimen is also vesicular, so the result is also too low. A small chip from the larger specimen of No. 24 was fairly compact, but contained some vesicles. By the Joly's spring balance the specific gravity of the chip was determined at 2.60.

We may conclude that the true specific gravity exceeds this latter figure. The glass must therefore be basic in composition, i.e., the specimen is tachylyte. This is in agreement with Mr. Walcott's silica determination of 53.2 %

Specimen No. 24A ("Blue obsidian") is larger and quite compact. By Walker's balance the specific gravity is 2.74. This also indicates clearly that the specimen is tachylyte. I am quite at a loss to explain how Mr. Cosmo Newbery could have obtained the results quoted for the chemical analysis of these specimens or the figures for their specific gravities (No. 24=2.41, No. 24A=2.36). It is clear, however, from Mr. Walcott's work and my own determinations of specific gravity that both specimens are tachylyte and not obsidian, as described.

Further, it is unfortunately clear that the older chemical analyses of rocks, etc., published by the Geological Survey of Victoria, must be regarded as quite untrustworthy.

This criticism must include in this connection not only the analysis of the "obsidian" from Geelong, but also the analysis of Specimen No. 21, an australite from Horsham, in which less than 5 per cent. of alumina is recorded, and over 10 per cent. of

alkalies, and also the "basalt" from the Coliban River, near Kyneton, in which 61.96 % of silica, 10.43 % of iron, and only 2.10 % of alkalies are recorded. These are published in the essay cited above, and are quoted without comment by Mr. Dunn. They must be regarded as quite unreliable.

The Taradale "obsidian."

Associated with pebbles of black basalt along the course of the Coliban River from the Upper Coliban Reservoir to Taradale, Mr. Dunn found and has described[1] well-rounded pebbles of what he calls black obsidian. Mr. Dunn first found these pebbles at Taradale. He quotes a first-class analysis made of this material by Mr. J. C. Watson, of the Geological Survey Laboratory, and for comparison the analysis by Mr. J. C. Mingaye, of N.S. Wales Geol. Laboratory, of a remarkable australite from Uralla, in N.S. Wales.

The analyses are as follow, with another for comparison :—

	(1) Taradale Obsidian.	(2) Uralla Australite.	(3) Diorite Porphyry.
SiO_2	63.67	64.68	62.18
Al_2O_3	15.83	16.80	15.77
Fe_2O_3	1.39	6.57	1.83
FeO	4.06	1.01	2.44
MgO	2.15	2.50	3.55
CaO	3.88	3.88	4.13
Na_2O	3.57	tr.	3.92
K_2O	3.69	4.01	3.91
H_2O+	0.02	—	0.70
H_2O-	0.15	—	0.30
TiO_2	1.27	—	0.55
P_2O_5	0.02	—	0.32
MnO	0.43	—	BaO 0.43
NiO and CoO	0.01	—	—
Total	=100.14	99.45	100.23
Sp. Gr.	= 2.569		

3. Diorite Porphyry, Steam Boat, Little Belt Mt., Montana. Analyst, W. F. Hillebrand. Described by L. V. Pirrson. Recorded in Chemical Analyses of Igneous Rocks by Washington, 1903, p. 222, United States Geol. Survey.

The Taradale rock is a remarkable one, and Mr. Dunn has done a distinct service to Victorian petrology in drawing attention to it, since it appears to be a type hitherto unrecognised among the recent

1. Op. cit.

volcanic rocks of Victoria. Until it has been found "in situ," and its relation to the basaltic rocks of the district has been determined it would be premature to give a detailed discussion of its characters.

A glance at the analysis, however, shows at once that it is not obsidian, as the relatively low silica percentage and the six per cent. of alkaline earths preclude this possibility. On the other hand it is clearly not a basalt in view of the high silica percentage, and the fact that the total alkalies exceed 7 per cent.

Through Mr. Herman, Director of the Geological Survey of Victoria, I obtained a small fragment of the material, from which the analysis was made, and had two rock sections made. The rock is clearly a volcanic glass and contains besides brown glass, globulites, trichites and scattered phenocrysts of olivine, augite and plagioclase felspar.

The minerals present show affinities with the basalts, but the large amount of glass is evidently high in silica and the alkalies.

It has long been known that in a molten basic magma in which crystals are floating the composition of the molten ground mass is generally more acid than that of the phenocrysts or of the whole rock. In Teall's British Petrography, pp. 399-401, analyses by Lagorio are quoted which show this effect, which is especially marked in rocks of intermediate composition and less marked in basic rocks. It is interesting to note that the glass of such rocks is richer in silica and in the alkalies than is the parent rock. It is this richness in silica and the alkalies which makes the Taradale rock interesting, and suggests that it may represent the glass from a basaltic magma from which the bulk of the phenocrysts are wanting.

The closest approach to the composition of the Taradale rock is an analysis of a diorite-porphyry from Montana, quoted above.

The norms of the Taradale rock and of the Montana rock, and of the Uralla australite are as follow :—

	Taradale Rock.	Diorite Porphyry.		Uralla Australite.
Quartz	15.66	11.2		37.2
Orthoclase	21.68	22.8		23.9
Albite	30.39	33.0		—
Anorthite	16.12	13.9		19.2
Diopside	2.51	5.3	Corundum	5.4
Hypersthene	9.06	8.1		6.2
Magnetite	2.09	2.6		3.9
Ilmenite	2.43	1.1	Hematite	3.8

In the American classification both rocks belong to—

Class 2. Dosalane.
Order 4. Dofelic.
Rang 2. Domalkalic.
Sug-Rang 3. Sodipotassic.

Their magmatic name is Adamellose.

This comparison shows that in chemical composition the Taradale rock belongs to the basic end of the intermediate class, while the mineral phenocrysts and apparently its field occurrence suggest a genetic relationship with the basalts. It is quite clear that the rock is not obsidian.

This analysis of the evidence of the so-called obsidian from Geelong and from Taradale shows that Mr. Dunn's claim that acidic volcanic glass, similar in composition to that of australites, exists in Victoria associated with the newer volcanic rocks, is quite unwarranted by the evidence so far available.

The chemical characters of australites.

The literature on australites, obsidianites, or obsidian buttons as they were formerly called, is now voluminous. The best papers describing the physical characters of these bodies are Mr. Walcott's[1] and Mr. Dunn's.[2]

The illustrations in Mr. Dunn's paper are particularly valuable. From the point of view of origin and chemical relationships the most important papers are by Dr. Summers[3] and Dr. Suess.[4] Dr. Summers has given the most complete discussion of their origin from a chemical standpoint, and has given a fairly complete bibliography of the literature, which it is unnecessary for me to repeat.

Among the hypotheses as to the origin of australites are the following :—

1. That they are artificial bodies.
2. That they have been formed by lightning discharge during dust storms.
3. That they are of volcanic origin.
4. That they are of meteoritic origin.

For the first two hypotheses no serious evidence or arguments have been advanced.

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1. Walcott. Proc. Roy. Soc. Victoria, vol. xi., (n.s.), 1898.
2. Dunn. Records Geol. Surv. Victoria, vol. ii., pt. iv., 1908. Bulletin Geol. Surv. Vict., No. 27, 1912.
3. Summers. Proc. Roy. Soc. Victoria, vol. xxi. (n.s.), pt. ii., 1909; Aust. Assoc. Adv. Sc., Melb., 1913.
4. Suess. Jahr. d. k.k. Geol Leichaust. Vienna, vol. 50, 1900, p. 194.

The volcanic hypothesis was once commonly held until the examination of recent volcanic rocks in Australasia and the absence of similar forms from any known active volcanoes made the explanation of their composition and distribution difficult.

Dr. Summers has clearly pointed out that though these bodies have been called obsidianites, the material is not obsidian, and differs from it in certain notable chemical characters, especially the low alkali percentage, and the relatively high percentage of the alkaline earths, the latter being normally in excess of the former, whereas the reverse relation is true of obsidian.

Comparison of the Taradale so-called obsidian with the Uralla australite.

Mr. Dunn has made a comparison of the chemical composition of the Taradale rock with that of the Uralla australite, and comes to the conclusion that the two rocks are practically identical and both are obsidian. I have shown that the Taradale rock is not obsidian, neither for that matter is the Uralla australite. Neither are the two rocks identical. It is true that the percentages of silica alumina and alkaline earths are fairly comparable, but the percentages of soda and of oxide of iron, especially ferric oxide, are widely different.

Two ways exist of comparing analyses, each of which is more illuminating than a simple comparison of oxides. The one method is by a comparison of the norms determined on the American classification. These are shown above (p. 338), and show wide differences.

The other method is by the drawing and examination of "variation curves," as utilised by Dr. Summers in his recent paper.[1] By this method variations of composition within the limits of a rock species can be shown to lie along a curve, and not only so, but where a number of different rocks in a district have a genetic relationship with one another this is brought out clearly by the fact that all the related types conform to the curves. On the other hand if two or more rocks are not so related this difference is indicated by a lack of conformity between the curves representing the different rocks.

I have made such a comparison of "variation curves" between the curves of the Uralla australite and that of the Taradale rock.

1. Op. cit.

The Uralla australite while quite extreme in chemical composition is shown by Dr. Summers to lie on a curve containing most of the australites which have been analysed. In the case of the Taradale rock the points for ferrous oxide, soda and total alkalies lie a long way outside the main curve of most of the australites.

The comparison of the two types by both methods, therefore, indicates their essential dissimilarity and the dissimilarity between the Taradale rock and australites in general.

Incidentally it may be noted that Mr. Dunn's comparison of the Taradale rock is not with Victorian australites, as one would expect, but with a New South Wales australite of quite extreme composition. This is curious since Mr. Dunn's claim is to establish a connection between australites and Victorian volcanic rocks. Of course a comparison with analyses of Victorian australites would have at once shown an almost complete dissimilarity of composition.

The complete failure up to the present of all attempts to locate any newer volcanic rocks in Victoria, or even in Australasia, which are similar in chemical composition to the australites, is a formidable difficulty in the way of the acceptance of a volcanic origin for these bodies. With the large and rapid increase of our knowledge of the newer volcanic rocks of Australasia, made in recent years, the probability of finding rocks of such peculiar composition becomes less and less, and the argument, though based on negative evidence, that the australites are not of volcanic origin has been proportionately strengthened.

Even if a volcanic rock of similar composition to that of the australites were found in Australia, the difficulties of the distribution of these bodies, in many cases hundreds of miles from any volcanic rocks, remains as has been pointed out by Dr. Summers. The shapes of these bodies, and especially the smooth nature of the flange, appear to me to negative Mr. Dunn's ingenious hypothesis that they represent the blebs of volcanic bubbles, a hypothesis put forward by Mr. Dunn to explain not only their form, but also their distribution.

It is the general failure of the volcanic hypothesis rather than positive evidence in favour of an extra-terrestrial origin which leads most modern writers on this subject to regard the meteoritic hypothesis of the origin of australites as the most probable one in view of the present state of our knowledge on the subject.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART II., 1914].

ART. XXIII.—*On Bitter Pit and Sensitivity of Apples to Poison.*

BY ALFRED J. EWART, D.Sc., PH.D.
(Professor of Botany and Plant Physiology in the Melbourne University).

[4TH PAPER].

[Read 12th November, 1914].

In 1913 Rothera and Greenwood made a direct attempt to test the poisoning theory of Bitter Pit, on the line that if the non-solution of the starch grains usually shown in Bitter Pit tissue is due to the action of the poison, a diastase solution after contact with Bitter Pit tissue should have its diastatic activity retarded. They stated, however, that with malt diastase and Taka diastase an accelerating action was shown. In the Proceedings of the Royal Society of Victoria, Vol. 26, p. 233, I showed, however, that they had overlooked the influence of the presence of tannic acid, and that even a short contact of 10 c.c. of 1 % Taka diastase with 20 grams of pounded apple pulp distinctly retarded the diastatic activity of the filtered extract. It is well known that tannic acid retards diastatic action, and this was supposed to be due to a direct action on the diastase. I showed, however, that tannic acid, even when dilute, precipitates starch from a watery solution, and thence concluded that the action was rather on the starch than on the diastase. This is borne out by the fact that the precipitating action is less pronounced at high temperatures, and that under these circumstances the retarding action of the tannic acid is also relatively less pronounced.

In replying to my criticism, Rothera and Breidahl reaffirm the existence of an accelerating action. This might be obtained under the following conditions :—(1) If a resistant and very active diastase such as Taka diastase is used in relatively large amount. (2) If the tests are made at high temperatures. (3) If dry bitter pit pulp in which the tannic acid has been oxidised is compared with fresh pulp rich in tannic acid.

I found that using equal volumes of 1 % taka diastase or malt diastase, of 1 % starch solution, and of tannic acid, the latter retarded the hydrolysis of starch down to concentrations of 0.005 to

0.001 % at 28° and 35° C. With larger amounts of tannic acid an apparent acceleration may be shown, but this is simply due to the tannic acid condensing and precipitating the starch, so that the liquid above gives yellow with iodine. If the whole of the remaining starch is precipitated with excess of tannic acid, filtered, dried and weighed, the control always contains less starch than the tube with tannic acid. To get the full retarding action, the diastase extract must contain no proteids capable of combining with and removing the tannic acid, and for this reason filtered malt diastase is more sensitive to the presence of tannic acid than unfiltered malt diastase. When the diastase extract is free from proteids capable of removing tannic acid, the retarding action is probably entirely due to the action of the tannic acid on the starch and not to an action on the diastase. In addition, I was able to show that dilutions of metallic poisons unable to destroy either oxidase or diastase were still poisonous to the living protoplasm of the apple and potato when applied externally. It is, in fact, a fairly general rule that enzymes are a little more resistant to dry and moist heat and to poisons than the protoplasm of the cells containing them, and hence the diastase method will only detect a poison when present in relatively large amount and in soluble form, and even then only when nothing else which affects diastatic action is present in the tissue.

At the September meeting of the Royal Society of Victoria, Rothera, together with Miss Kincaid and Miss Jackson, advanced a criticism of my work on the sensitivity of apples to poison. They stated that the poisoning effects obtained by me were not due to the poisons used at all, but to the action of the distilled water to which the apple pulp was exposed at the points where the cuticle had been removed. They based this conclusion on the following statements: —(1) Prepared apples floated on distilled water developed brown pits beneath the points from which the "cuticle" had been removed. (2) In isosmotic (isotonic) solutions of sodium chloride (2.5 % and upwards) to which poisonous solutions were added, no brown pits developed. (3) Peeled apple pulp floated on distilled water slowly turns brown, but remains colourless when floated in apple sap. They conclude, therefore, that in (2) and (3) the pulp cells are under normal osmotic conditions, and the pulp cells remain living, and that in (1) they are under abnormal osmotic conditions and therefore die. As a matter of fact the reverse is the case. No plant cell provided with a cell-wall can grow in a medium isosmotic

with the cell-sap. The essential feature of a typical plant cell as compared with an animal cell is that it avoids isosmotic conditions, and spends its whole life not quite in distilled water, but in a very dilute solution containing usually not more than one gram of dissolved solids in 1 to 2000 c.c. of water. This water saturates the cell-wall, and the strong solution inside the cell presses the semi-permeable protoplasm against the cell-wall, and stretches the latter until its distension balances the surplus osmotic energy of the cell sap when a condition of the hydrostatic equilibrium is reached. If the cell is now placed in an isosmotic solution of an impermeable salt, the cell wall is no longer stretched, no growth is possible, and the cell is in an entirely abnormal condition.

Scarlet Nonpareil apples of approximately the same shape and size were selected, only varying a few grams from 800 grams weight. After removing the cuticle from 15 points in areas of as nearly as possible 1 mm. diameter, the apples were weighed and floated in water and 2.5 salt solution for 1 week. The first apple gained 0.6 gram per cent. in weight, the second 0.057 grams. In a second experiment the calyx and stalk were covered with paraffin. In distilled water the apple absorbed 0.45 c.c. of water per 100 grams, in the salt solution it lost 0.03 c.c. In 0.5 % and 1.5 % solutions of sodum chloride distinct gains of weight were shown, but always less in the 1.5 % as compared with the 0.5 % solution, and in the latter as compared with distilled water, provided that the skin of the apples was without injury or crack so that water could enter only at the prepared points.

The amount of absorption will depend largely upon whether the osmotic pressure of the pulp cells is or is not fully satisfied in the apple before it is immersed in water. Hence it is important to use apples fresh from cool storage, in which the loss by transpiration has been slight. In the tests with very dilute poisonous solutions, a little of the solution is drawn into the apple at special points where the poisonous action is localised, in addition to the poison reaching the surface by diffusion. In one experiment with 1 per 100,000 copper sulphate, 0.4 gram of the solution was absorbed and 2.4 grams of tissue were poisoned, so that to poison 1 gram of the pulp cells required at least one millionth of a gram of anhydrous copper sulphate.

Although prepared apples soaked in 1.5 % and 0.5 % salt solutions absorb appreciable quantities of the solution, the prepared spots show at first sight no signs of poisoning and remain colourless

or nearly so, instead of turning brown. If fresh apple pulp is pounded up with 0.5 to 2.5 % solutions of sodium chloride, it does not turn brown, although the cells are completely killed. The pulp gives even after some hours a faint blue with guiacum, a strong one with guiacum and hydrogen peroxide, and a fairly rapid reaction with ursol tartrate. Salt, therefore, prevents the oxidation of tannic acid by apple oxidase without destroying the latter, and it is a sensitiser to the oxidase action on guiacum, which normally only turns blue with guiacum in the presence of hydrogen peroxide. I have already given specific instances of many similar specific "antioxidase" and "sensitiser" reactions, and have shown that the presence of salt affects various of the colour reactions of tannic acid, including its reaction with ferric chloride.

Owing to the action of salt in preventing browning it is difficult to determine its poisonous action. So far as can be judged by microscopic examination of the cells beneath the prepared spots where the salt solution is absorbed, it appears to belong to the class of almost non-poisonous salts as compared with mercury and copper salts, and to be less poisonous than potassium salts. With strong solutions osmotic injury is caused, but this is mainly confined to the surfaces of the prepared spots.

In regard to the statement that brown pits developed in apples floated on distilled water beneath the prepared spots from which the cuticle had been removed, I was fortunately able to examine subsequently the apples in question and to see that not only the cuticle but also the epidermis and hypodermis had been removed right down to the pulp tissue. The importance of not removing these layers is that they form continuous layers of cells without air spaces (except at the lenticels), and hence prevent the invasion of micro-organisms, which takes place very rapidly in water, particularly if any of the pulp cells have been injured or cut, and is soon followed by an invasion of fungal hyphae.

The browning of peeled pulp floated in distilled water is usually due to the action of micro-organisms. They can be seen in a few hours, and if the water is previously sterilised, all possible antiseptic precautions taken and the peeling done with a sharp razor, the browning of the pulp is very slow. Peeled pulp will remain fresh and living under kerosene for as long as 2 to 3 weeks, showing that the death of the pulp is not due to asphyxiation by drowning. In fact, apples remain living for some weeks in an atmosphere of nitrogen or hydrogen.

When immersed in its own sap living pulp usually remains unbrowned for some time if the sap has been previously sterilised by boiling. The soluble matters in this sap are impermeable to the living protoplasm, just as they are when inside the cell. No penetration therefore takes place, and the tannic and other acids of the sap prevent or retard the development of bacteria. Such pulp is, however, readily invaded by fungal hypae.

In all cases, for a poisoning effect to be exercised the poison must be able either to penetrate the protoplasm or to injure its ectoplasmic membrane. A curious point worth noting here is that the protoplasm of the pulp cells is, as one might expect, resistant to tannic acid. This is probably due to the formation of an impermeable coagulation film on the surface of the ectoplasmic membrane, such as must exist normally on the endoplasmic membrane. This membrane appears to increase the impermeability of the protoplasm, especially to organic acids (malic, citric, tartaric, oxalic), and hence in the presence of tannic acid externally applied, solutions of these acids are only poisonous in considerably increased concentration. This may explain the remarkable effectiveness with which the delicate pulp cells retain their sugary and acid contents, although some of the acids when applied externally are poisonous.

It is perhaps hardly necessary to say that in my own work these possibilities of error were detected early. Every experiment was done with a control in distilled water. These controls were unaffected, and, in fact, properly prepared apples can be kept almost as well floating in distilled water as ordinary apples can be kept in air. In addition the results were throughout consistent—i.e., with increasing dilution less and less poisoning effect was exercised. In order to settle this matter finally, I arranged to perform these experiments before a committee consisting of Dr. Hall, President of the Royal Society, Professor Osborne, Dr. Rothera, Miss Kincaid and Miss Jackson. All the apples were prepared by me. In the whole series about 260 removals of the cuticle from usually 10 to 12 points in each apple took place. In about 5 or 6 cases the cut was a little below the cuticle. Part of the solutions (series A) were prepared by myself, part (series B) by Dr. Rothera, Miss Kincaid and Miss Jackson. The apples were placed in the solutions by one of the three foregoing. They were kept in a locked cupboard by Dr. Hall and inspected jointly after 3 and 7 days' immersion. The solutions were then poured away, the apples and cylinders washed with distilled water, left for a week

in moist air and examined by the members of the committee. The average temperature was 15°-18° C. Dr. Rothera brought Gravenstein apples for testing. I preferred Yates' Pippin, which is a hard-fleshed, resistant apple, much less sensitive to poisons but always unaffected by distilled water if properly prepared.

The results of the test are as follows :—

Series A.—Yates' Pippin.

Controls.

Distilled water.

(1) No pits, browning or signs of poisoning on any of the prepared spots.

(2) No pits, browning or signs of poisoning on any of the prepared spots.

Copper Sulphate.

(3) 1 per 100,000. Well-defined brown pits 1-2 mm. deep on all prepared spots.

Lead Nitrate.

(4) 1 per 100,000. Doubtful.[1]

Mercuric Chloride.

(5) 1 per 10,000. Large pits 1-3 mm. deep.

(6) 1 per 100,000. Small brown pits 1-2 mm. deep on all the prepared spots.

(7) 1 per 1,000,000. Doubtful.[1]

Series B.—All Gravenstein apples except in the case of 6 (b), 8 (b), 9 (b) and 10 (b), where Yates apples were used.

Controls.

Distilled water.

(1) No browning, pits or signs of poisoning on any of the prepared spots.

(2) Light brown irregular pits beneath three contiguous prepared spots, possibly over a slightly bruised area, the other nine spots quite unaffected.

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1. I could see distinct signs of poisoning on these apples, but as Dr. Rothera could not, they are given as doubtful. Lead nitrate rapidly destroys oxidase and penetrates slowly. Lead nitrate pits are always pale, copper sulphate ones much darker.

Mercuric chloride.

(3) 1 gram per 10,000 c.c. All the spots with brown pits 2-4 mm. deep.

(4) 1 gram per 100,000. All the spots with brown pits 1-3 mm. deep.

(5) 1 gram per 1,000,000. All the spots with brown pits 1-2 mm. deep.

(6) 1 gram per 100,000 in 3 % sodium chloride.
- (a) Browned and invaded by Penicillium.
- (b) Yates. Rather pale pits to all the prepared spots 1-2 mm. deep.

(7) 1 gram per 10,000 in 3 % sodium chloride. Large deep pits to all the prepared spots 4-6 mm. deep.[1]

(8) In 3 % sodium chloride alone.
- (a) From superficial browning to pits ½ mm. deep.
- (b) Yates. Superficial browning. No distinct pits.

Copper Sulphate.

(9) 1 per 10,000 in 3 % sodium chloride.
- (a) Large well-defined pits 2-3 mm. deep, but paler than with copper sulphate alone.
- (b) Yates. Large pits, but apple invaded by Penicillium through a bruise.

(10) 1 per 100,000 in 3 % sodium chloride.
- (a) All the prepared spots browned, pits pale, barely exceeding 1 mm. deep.
- (b) Yates. As above, but pits not exceeding 1 mm.

(11) 1 per 100,000 (copper sulphate alone).
Large dark pits to all the prepared spots 3-4 mm. deep.

These results closely coincide with those already published by me, and show that dilute metallic poisons produce browning and pit formation in the presence of isosmotic solutions of sodium chloride, the entry here taking place by diffusion only. Further, Gravenstein apples appear to resemble Five Crowns in their greater sensitivity as compared with Yates. In a pale-skinned apple it is difficult to be sure that the cut has not gone too deep, whereas in a red apple the fragments removed from the skin must show no colour. If they do, the cut has passed through the hypodermal layers. Further, in soft-fleshed apples some of the prepared spots may be

1 The mercuric chloride kills the cells before sufficient salt has entered to prevent browning.

made over slightly bruised areas, which will subsequently give an imitation of irregular pit formation. It was owing to the occasional unreliability of the controls that I abandoned in my first paper the use of pale-skinned, soft-fleshed apples. Even in such cases, however, an element of doubt only creeps in in determining the lowest limits of the poisonous concentrations. In the stronger solutions every prepared spot shows a brown pit which has a well-defined area centric to the prepared spot, and does not spread beyond a sharp boundary zone. If when using a soft-fleshed or pale-skinned apple, an occasional prepared spot on the control develops an apparent "poison" pit; this is usually a pale colour. If it is due to a bruise it will be irregular and not centric around the spot. If it is due to too deep a cut admitting micro-organisms it will slowly develop further in moist air, but the other prepared spots will be unaffected. If it is due to an invasion of fungal hypae, it will spread rapidly through the whole apple and the pulp will become soft and watery.

I might perhaps add that if red-skinned, hard-fleshed apples are used, this method forms the best possible class experiment to demonstrate—

(a) the indifference of the plant-cell to distilled water;
(b) the importance of the cuticle;
(c) the extreme sensitivity of the pulp cells to metallic poisons.

For class experiments the best solutions to use are 1 gram per 100,000 of mercuric chloride or copper sulphate, and the method can be used to some extent to test the freedom of distilled water from small amounts of soluble metallic poisons.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART II., 1914].

ART. XXIV.—*New or Little-known Victorian Fossils in the National Museum.*

PART XVII.—SOME TERTIARY CEPHALOPODA.

BY FREDERICK CHAPMAN, A.L.S., &c.

(Palaeontologist to the National Museum, Melbourne).

[With Plates III.-VIII.]

[Read December 10th, 1914].

Introductory Note.

The series herein discussed comprises examples of cephalopod shells, some of which have been in the collection for many years In the case of the genus *Nautilus* the fossils are generally fragile, or are only known as casts, so that it is often impossible to get quite perfect representatives which would serve as complete types. These specimens, imperfect as they are, nevertheless afford many characters of differentiation which will serve to distinguish the several forms; and, indeed, the only named Australian Tertiary species of the genus *Nautilus* (*N. geelongensis*), was originally described from an imperfect cast by Mr. A. H. Foord in his British Museum Catalogue of Cephalopoda. It seems, therefore, in the interests of systematic work upon Victorian Tertiary fossils to place on record, without further delay, some of the chief of our cephalopod fossils of this latest geological era.

The present collection comprises the following forms :—

Aturia australis, McCoy.
Nautilus balcombensis, sp. nov.
,, *geelongensis*, Foord.
,, *altifrons*, sp. nov.
,, *felix*, sp. nov.
Notosepia cliftoni, gen. et sp. nov.

DESCRIPTION OF THE FOSSILS.

TETRABRANCHIATA.—Order NAUTILOIDEA.

Fam. CLAUDONAUTILIDAE, Hyatt.

Genus **Aturia**, Bronn.

Aturia australis, McCoy. (Plate III., Fig. 2).

Nautilus ziczac, T. Woods, 1862, Geol. Observ. in S. Australia, p. 83, woodcut.

Aturia australis, McCoy, 1867, On the Recent Zoology and Palaeontology of Victoria, Ann. Mag. Nat. Hist., ser. 3, Vol. XX., p. 192. Brough Smyth, 1874, in Geol. Surv. Vic.; Report of Progress, p. 36.

Aturia ziczac, Sow. sp., var. *australis*, McCoy, 1876, Prod. Pal. Vict., dec. III., p. 21, pl. XXIV., figs. 1-5.

Aturia ziczac, Sow. sp. Etheridge junr., 1878, Cat. Austr. Fossils, p. 171.

Aturia aturi, Basterot sp., var. *australis*, McCoy, Foord, 1891, Cat. Fossil Cephalopoda (Brit. Mus.), pt. II., p. 354; also p. 336, fig. 71b.

Aturia australis, McCoy, Dennant and Kitson, 1903, Cat. Fossils Cain. Fauna Victoria, Rec. Geol, Surv. Vict., Vol. I., pt. 2, p. 92.

Observations.—The Australian form of the type of *Aturia aturi*, Basterot, has been the subject of wavering opinion amongst palaeontologists as to its specific or varietal standing. The present study of a large number of Australian specimens seems to show that it is a distinct form, having some marked characters which help to distinguish it from the Burdigalian species of France and Italy.

McCoy in 1876 (vide supra p. 21), remarked that "It is with the compressed Miocene variety found at Dax, named N. Aturi by Basterot, rather than with the more ventricose original types of the N. zizac of Sowerby, proper to the Eocene London clay, that our Australian fossil more completely agrees; and I can only doubtfully suggest the separation of it as a local variety, from the somewhat greater compression indicated by the slightly greater length of the aperture in proportion to its width; and also a slightly greater curvature of the septa on the sides as shown by a line from the apex of the lancet-shaped lobe to the inner end of the same septum, encroaching rather more on the third chamber behind."

Mr. A. H. Foord in his British Museum Catalogue has taken the same standpoint as McCoy, and regarded it as a variety, the specific

type being *Aturia aturi.* Foord says (op. cit. p. 355), "This variety closely resembles the Dax specimens of *Aturia aturi;* a specimen from "Muddy Creek," Victoria (Australia) being quite indistinguishable at first sight from the Dax fossils. On comparing, however, a specimen of the latter with the Muddy Creek shell, both being of equal size, it is found that the Australian shell has a larger siphuncular orifice than the Dax specimens, thus adding another point of difference to those indicated by McCoy as existing between the two forms."

Quite recently M. Vignal, of Paris, has favoured the Museum with a specimen of *Aturia aturi*, of Burdigalian age, from Dax, Landes, France. On comparing this specimen with Australian examples, the following features, already pointed out by McCoy and Foord are seen:—

(1) The Australian shells are more compressed.

(2) The septa and growth-lines are more strongly recurved towards the periphery.

(3) The siphuncular orifice is larger.

In view of the above-named characters, which are constant so far as my own observations go, there are justifiable grounds for keeping the Australian form as a distinct species, at the same time bearing in mind that its relationship is nearest *Aturia aturi.* It is only fair to state, however, that Mr. R. B. Newton, during his visit with the British Association to Melbourne this year, informed us at the sessional meeting that he and Mr. G. C. Crick, of the British Museum of Natural History, are agreed to consider our Australian species as identical with *Aturia aturi.* Probably did the London Museum possess a larger comparative series of the Australian form, that view might undergo some modification, and it is to be regretted that Mr. Newton did not have time to critically examine the series of *Aturiae* in the Melbourne National Museum.

C. F. Parona in 1899 described from Gassino, Piedmont, an Upper Eocene or Oligocene Aturia under the name of *A. rovasendiana.*[1] This species has a compressed shell after the mode of *A. aturi*, but in the structure of the septation it shows more affinity with *A. ziczac* and its allies. This species thus appears to indicate a connecting link between the palaeogene and neogene aturids.

Occurrence and Horizons.—The related European *Aturia aturi* is, so far as I can discover, typically found in Miocene beds in

1 Pal. Ital., vol. iv. (1898), 1899, p. 156, pl. xii., fig. 1; pl. xiii., figs. 1-3.

2 Foord. Brit. Mus. Cat., supra cit., p. 354 ("London Clay.")

France, Malta and Italy, although recorded, apparently in error, from the Lower Eocene, since no Eocene locality is given in the list that follows. The Australian species on the other hand, has a very extensive range, from Oligocene to Lower Pliocene, and throughout seems to maintain its specific characters.

Oligocene or Balcombian.—Muddy Creek, near Hamilton (lower beds), Newport and Altona bores, Port Phillip. Balcombe Bay and Grice's Creek, Port Phillip.

Miocene or Janjukian.—Gellibrand River (low down in series). Brown's Creek, Otway Coast. Birregurra. Lower Moorabool, Mitchell River, Gippsland. Mount Gambier, South Australia. Table Cape, Tasmania. Spring Creek, near Torquay. Flemington, near Melbourne.

Lower Pliocene or Kalimnan.—Beaumaris.

Fam. NAUTILIDAE, Owen.

Genus **Nautilus**, Linné.

Nautilus balcombensis, sp. nov. (Plate III., Figs. 3, 4; Plate IV. Figs. 5, 6; Plate VIII., Figs. 18, 19).

Description.—Shell well inflated, periphery well rounded. Dorsal arch not so deep as in *N. geelongensis.* Septa, about 17 in the last whorl; sutures slightly waved. Umbilicus narrow and deep. Siphuncle a little above the centre in a young specimen. Young examples show a striated surface of shell, as in adult forms from mesozoic strata.

Dimensions.—Type specimen (from Balcombe Bay): greatest diameter, 205 mm.; height of aperture, 118 mm.; width, 110 mm. Another specimen (from Muddy Creek): greatest diameter, 80 mm.; height of aperture, 45.5 mm.; width, 42 mm. A small specimen (from Balcombe Bay): Height of aperture, 23 mm.; width, 26 mm.

Affinities.—This Nautilus attains to a large size, but is very difficult to secure in anything like a complete state owing to the thinness of the shell, and its frequent occurrence in loose, shelly marl. The type of shell is near *N. regalis*, Sowerby,[1] but, unlike that species, has an open, though narrow umbilicus. At first sight it might be confused with *N. geelongensis*, as a compressed variety, but the latter species has fewer chambers, a more strongly arched dorsum, and a siphuncle situated slightly below the centre. The

1 Mineral Conchology, 1882, vol. iv., p. 77, pl. 355.

sides of *N. geelongensis* are also more strongly convex, and proportionately broader, whilst the body chamber in *N. balcombensis* is higher and more nearly equal to the width, which it exceeds in the later stages.

Occurrence and Horizon.—The type specimen is from Balcombe Bay; collected and presented by Mr. F. A. Cudmore. This particular specimen must have lain for some time on the Balcombian sea-bed, since there are numerous attached valves of *Dimya dissimilis*, Tate, adherent to the exterior of the shell.

Other specimens, presented by Mr. Cudmore, from the same locality, are in the brephic and neanic stages. Another example, in the Museum collection, in the ephebic stage, was collected by the writer from Muddy Creek (lower beds). All the examples are from strata of Balcombian age.

Nautilus geelongensis, Foord. (Plate IV., Figs. 7-9).

Nautilus geelongensis, Foord, 1891, Cat. Foss. Cephalopoda (Brit. Mus.), part II., p. 332, woodcut fig. 69.

Description.—The following diagnosis is quoted from A. H. Foord :—

"Sp. Char. A number of detached casts of the chambers which, when fitted together, make up a shell of a somewhat inflated form, rather compressed on the sides, and broadly rounded on the periphery. The aperture would be considerably wider than high. The septa are moderately distant, the sutures very slightly flexuous, with a dorsal lobe in the young shell. . . . The siphuncle is nearly central, perhaps a little below the centre. Not a vestige of the shell remains."

The above description, based on a cast, gives the chief points about the form of this species. Judging by the figure given by Foord, the type specimen would possess about 15 chambers on the last whorl, and this number coincides with the examples I have identified as *N. geelongensis* in the Museum collection. It occurs throughout the Miocene proper, or the Janjukian series of Victoria, but chiefly in the form of a cast of the interior of the shell. The shell is occasionally met with, but the beds in which it is found are not usually favourable for the extraction of the fossil in anything like completeness. Only one such shell is preserved in the Museum collection. The shell is moderately thin, and the outer layer conspicuously marked with growth lines. The umbilicus is apparently nearly closed; the sutures slightly flexuous.

Casts of the interior of the shell of this species, from the Murray River cliffs, show that the annular lobe on the dorsum or impressed zone is very distinct in the earlier camerae, but become fainter, and disappear on reaching the ephebic stage of the shell. It is interesting to note in connection with the presence of the annular lobe in this species, that it is also seen in another Australian form, *N. felix*, but less strongly developed.

Dimensions.—The type specimen of *N. geelongensis*, figured by Foord (op. cit. p. 333, fig. 69), has a maximum diameter of about 114 mm. The height of aperture is about 45 mm., and the width 63 mm.

A shell from Fyansford shows, height of aperture from impressed zone to periphery, 25 mm.; width, 32 mm.

Another specimen (cast), from the Murray River, measures on the aperture about 67 mm. in height, and 89 mm. in width.

Observations.—This species is apparently the commonest and best known of the Victorian Tertiary nautili, since it is a typical form in the widely developed Janjukian series, although ranging into the Kalimnan. Occurring so often in polyzoal rock, however, it is met with generally in the form of an internal cast of the shell. This is obviously due to the great solvent processes continually proceeding in and through this porous limestone. The characters and form of the original shell are so often clearly shown in the casts, as to leave no room for doubting the identity of the species. The general form of *N. geelongensis* is like that of *N. imperialis*, Sowerby,[1] but is not so wide at the aperture.

Occurrence and Horizon.—The original locality, "near Geelong," is somewhat vague, as it may have come from any of the chalky or polyzoal limestones within a wide radius in that district. All of those localities, however, would belong to the Janjukian series. Casts of *Nautilus*, probably of this species, occur in South Australia, in the white and yellow limestone of the Murray cliffs. A cast of *N. geelongensis* preserved in the white polyzoal limestone of that locality was presented by the late Rev. C. S. Y. Price, to whom the Museum has been indebted from time to time for many valuable specimens.

The small example, having the shell preserved, was collected by Mr. J. F. Mulder, at Fyansford, the deposit at which locality I now include in the Janjukian series.

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1 Min. Conch., vol. i., 1812, p. 9, pl. i.

From the Kalimnan series (Lower Pliocene) at its base, a fine example of *N. geelongensis* has been collected by Mr. Kurtze, of Hochkirch, which specimen was subsequently presented to the Museum by Mr. C. French, junr. It occurred in a gypsum-bearing bed, opposite Mr. Henty's farm, on the Grange Burn, associated with *Ostrea manubriata* and *Natica cunninghamensis*, and is itself partially filled with selenite.

Nautilus altifrons, sp. nov. (Plate V., Figs. 10-12; Plate VI., Fig 13).

Description.—This species is of moderate to large size. It is remarkable for the compressed form of the shell, and its consequently high apertural front. The chambers number about 15 to 17 in the last whorl. The umbilicus is open and deep, but not of great width; it has the appearance of being stepped, owing to the compression of the sides of each turn of the shell. The sutures are more undulate than in *N. geelongensis*, from which it is further distinguished by its depressed form, and almost quadrate aperture. Siphuncle sometimes preserved by the infilling of the shell with selenite, when it is seen to be ventral in position.

Dimensions.—Greatest diameter of type specimen, about 225 mm.; width of umbilicus, 13 mm.; height of aperture, 124 mm.; width, 103 mm.

Affinities.—This form of *Nautilus* is of the *N. urbanus* type, of the London Clay, near London, and the I. of Sheppey. In *N. urbanus* the siphuncle is described by Edwards[1] as dorsal in position, whilst in the present species, *N. altifrons*, as seen in the remarkably fine selenite casts, it is decidedly ventral.

Occurrence and Horizon.—*N. altifrons* appears to be restricted to Janjukian strata. It occurs at the Murray River cliffs (type), where it is found preserved in gypsum of the clear variety selenite, which mineral has invaded the chambers, whilst the shelly septa and siphuncle are often well preserved. A cast of this species in white polyzoal limestone from Nor'-west Bend, Murray River, South Australia, is also found in the Museum collection. A cast of *Nautilus*, probably referable to this species, occurring at Bairnsdale, was presented by Mr. W. A. C. a'Beckett.

1 "Mon. Eocene Cephalopoda and Univalves of England," vol. i. (Pal. Soc.), 1849, p. 46.

Nautilus felix,[1] sp. nov. (Plate VI., Fig. 14; Plate VII., Fig. 15).

Description.—Shell somewhat compressed, or only moderately inflated, with a well rounded periphery; whorls increasing rapidly. Camerae high, and with the sutures slightly undulate; few in number, nine in the last whorl. A feeble annular lobe on the impressed zone. Umbilicus rather wide and deep. Aperture roundly dome-shaped; higher than wide.

Dimensions.—Maximum diameter of shell in type specimen, 85 mm.; minimum diameter, 63 mm.; height of aperture, 47 mm.; width, 42 mm.; width of umbilicus, 7.5 mm.

Observations.—This form differs in many respects from any other known Victorian species. Its salient characters are—its compressed form compared with *N. balcombensis* and *N. geelongensis*, the wide umbilicus, and the small number of camerae in each whorl.

Occurrence and Horizon.—Happy Valley, South Australia (*Magellania pectoralis* beds)[2] Janjukian (Miocene). Type specimen in the Dennant coll.

DIBRANCHIATA.

Fam. SEPIOPHORIDAE.

Genus **Notosepia**, gen. nov.

Notosepia cliftonensis, sp. nov. (Plate VII., Figs. 16, 17; Plate VIII., Figs. 20-22).

Description.—Shell or sepion large and comparatively thick, but variable in the latter respect, according to habitat; triangulary ovate in ventral aspect. Alveolus moderately deep, filling up with age. Ventral lip of alveolar border recurved, and sometimes quite pendent; inner surface of lip radiately grooved or fluted. Back and sides of sepion coarsely reticulated or labyrinthic, and spongy. Vestigial septation of the internal surface of the pro-ostracum faintly marked, but stronger than in the living *Sepia*. Pro-ostracum strongly convex dorsally, at the anterior end becoming depressed and marked with strongly-arched lamellar growth-lines. Mucro thick, cylindrical, and bluntly terminated; in fully grown specimens directly in line with the back of the pro-ostracum, but in younger specimens having a slight tendency to recurve.

1 Name suggested by its occurrence at Happy Valley.
2 For notes on this deposit see H. Basedow, Trans. R. Soc. S.A., vol. xxviii., 1904, p. 248.

Dimensions.—Approximate length of type specimen (including impression of the anterior part of the pro-ostracum), 132 mm.; width of anterior extremity of pro-ostracum, 63 mm.; thickness of ventral lip of alveolus in type specimen, 8 mm.; approximate length of mucro, measured dorsally from the basal sinus at junction with the pro-ostracum, 13.5 mm. Distance from centre of alveolus to edge of lip, 21.5 mm.

Relationships.—Presumably on account of the thickened ventral lip of the alveolar border, and the strong mucro, the present species has been listed by some Australian authors in the genus *Belosepia.* Although characters such as those mentioned, agree with *Belosepia*, yet the latter genus is distinct in several essential characters, and these may be tabulated as follows:—

	Belosepia (Middle Eocene).	Notosepia (Oligocene).	Sepia (Living).
Dorsum	Strongly convex anteriorly; vellicate posteriorly.	Strongly convex.	Flatly convex.
Alveolar cavity	Deep and conical; inner surface with distant septation.	Moderately deep; inner surface with faint septation.	Shallow; inner surface with faint transverse lamellae.
Alveolar lip	Greatly extended, flabelliform.	Moderately thick, overhanging.	A sharp projecting border.
Mucro	Large, thick and bent backward.	Moderately large, thick, bent backward in young form, afterwards straight.	Small, generally slender, and either straight, or bent backward or forward.

It is especially noteworthy that young individuals of *Notosepia*, in having a recurved mucro, point to the older *Belosepia* type of shell; whilst the straight mucro of the adult form agrees more nearly with that of the living Sepia, in which it is normally straight, or only slightly bent.

Observations.—A large portion of the inner surface of the anterior region of the pro-ostracum in the type specimen, was fortunately preserved in collecting the specimen, and this materially adds to our knowledge of the form of the complete sepion. The pro-ostracum is thin and expanded, as in *Sepia,* and bordered by a wrinkled sub-chitinous membrane.

Practically all the specimens of *N. cliftoni* in the collection had lain on the sea-bed for some considerable time before being covered up, for the interior of the pro-ostracum generally carries attached organisms, as polyzoa and *Dimya* (right or attached valves).

Occurrence and Horizon.—The type specimen was presented to the Museum by Mr. F. P. Spry, and was collected by Mr. H. Lodge at Clifton Bank, Muddy Creek, from the upper, brown polyzoal marls of Balcombian age. It also occurs in the lower, blue marls of the same series. There is a specimen in the Dennant coll., from the same locality, and several examples in theMuseum coll., found by the late Mr. W. Kershaw, at Balcombe Bay and Grice's Creek, Port Phillip. These latter examples are of slightly thinner build, indicative in all probability of their deeper water habitat, as compared with the deposits at Muddy Creek.

EXPLANATION OF PLATES.

Plate III.

Fig. 1.—*Aturia aturi*, Basterot. Broken shell, showing the character and arrangement of the siphuncular funnels. Of Burdigalian age. Dax. Nat. size.

Fig. 2.—*Aturia australis*, McCoy. Broken shell, showing the internal structure. Balcombian. Grice's Creek, Port Phillip. (Coll. J. F. Bailey). Nat. size.

Fig. 3.—*Nautilus balcombensis*, sp. nov. Exterior of shell of type specimen, lateral aspect; with attached valves of *Dimya dissimilis*. Balcombian. Balcombe Bay, Port Phillip. (Coll. F. A. Cudmore). 7-17 nat. size.

Fig. 4.—*N. balcombensis*, sp. nov. Opposite face of the same shell, showing the internal concameration. About $\frac{2}{3}$ nat. size.

Plate IV.

Fig. 5.—*N. balcombensis*, sp. nov. Apertural aspect of the same shell. Slightly less than half nat. size.

Fig. 6.—*N. balcombensis*, sp. nov. Apertural aspect of an example in the neanic stage. Balcombian. Balcombe Bay, Port Phillip. (Coll. F. A. Cudmore). Paratype. Nat. size.

Fig. 7.—*Nautilus geelongensis*, Foord. A cast in polyzoal rock. Janjukian. Murray Cliffs, South Australia. (Coll. Rev. C. S. Y. Price). 3-5th nat. size.

Fig. 8.—*N. geelongensis*, Foord. Shell infilled with gypsum. Kalimnan. Cliffs opposite Henty's farmstead, Grange Burn, near Hamilton, Victoria. Lateral aspect. Nat. size.

Fig. 9.—*N. geelongensis*, Foord. Apertural view of the above specimen. Nat. size.

PLATE V.

Fig. 10.—*Nautilus altifrons*, sp. nov. Type specimen. Lateral aspect. Janjukian. Murray River Cliffs, South Australia. About 4-10th nat. size.

Fig. 11.—*N. altifrons*, sp. nov. Apertural aspect of the above. About 4-10th nat. size.

Fig. 12.—*N. altifrons*, sp. nov. Portion of a shell infilled with selenite; showing the septa and siphuncle preserved in situ. Janjukian. Murray River Cliffs, South Australia. Nat. size.

PLATE VI.

Fig. 13.—*Nautilus altifrons*, sp. nov. A cast in polyzoal limestone. Janjukian. Nor'-west Bend, Murray River, South Australia. Paratype. About 3-5th nat. size.

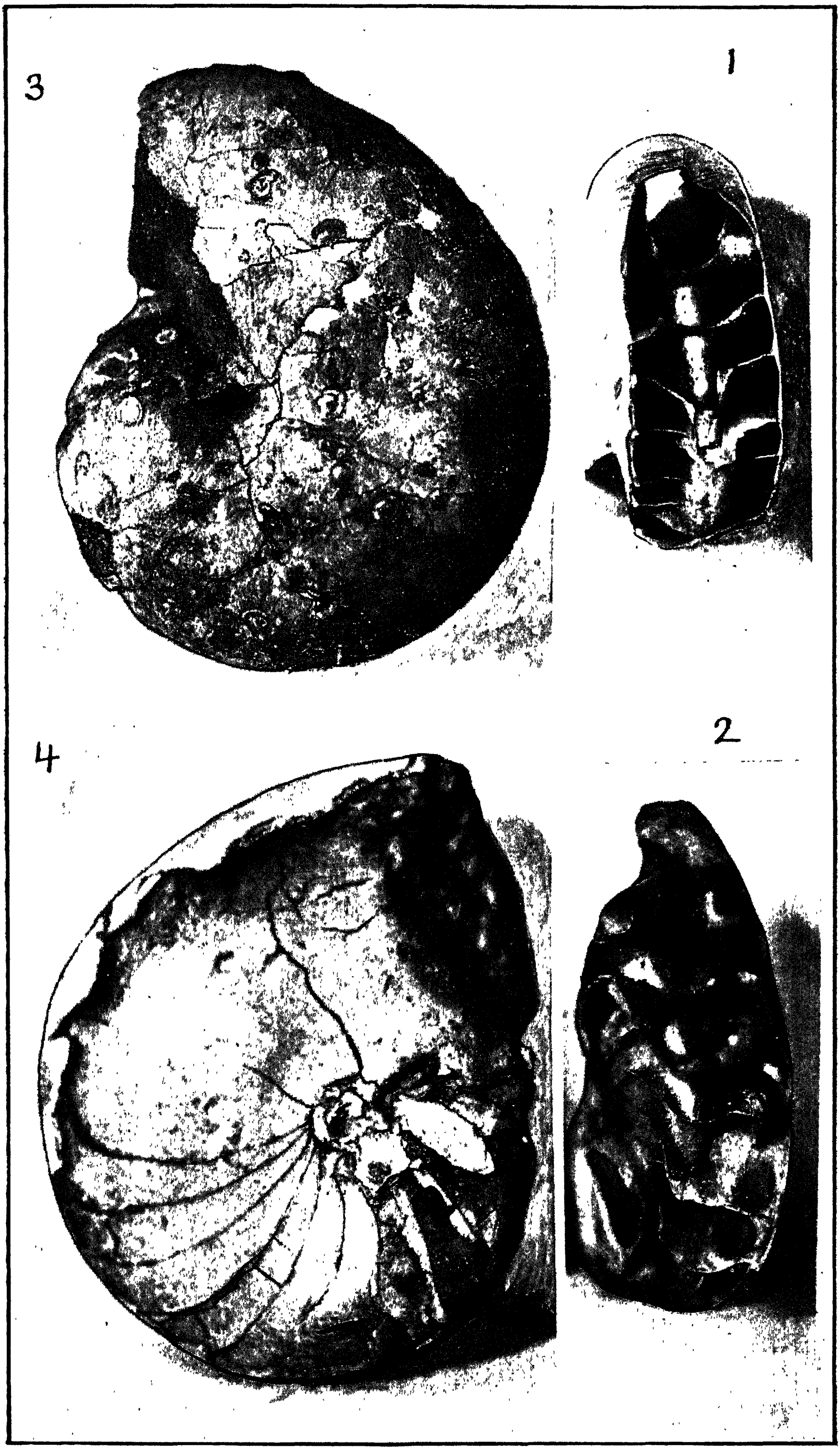
Fig. 14.—*Nautilus felix*, sp. nov. Lateral aspect of type specimen. A siliceous internal cast; with portion of the shell preserved. Janjukian. Happy Valley, South Australia. (Dennant coll.). About nat. size.

PLATE VII.

Fig. 15.—*N. felix*, sp. nov. Apertural aspect of the above specimen. About nat. size.

Fig. 16.—*Notosepia cliftonensis*, sp. et gen. nov. Internal face of sepion of type specimen. Balcombian. Clifton Bank, Muddy Creek, near Hamilton, Victoria. (Coll. H. Lodge). Nat. size.

Fig. 17.—*N. cliftonensis*, sp. nov. Side view of above specimen. Nat. size.



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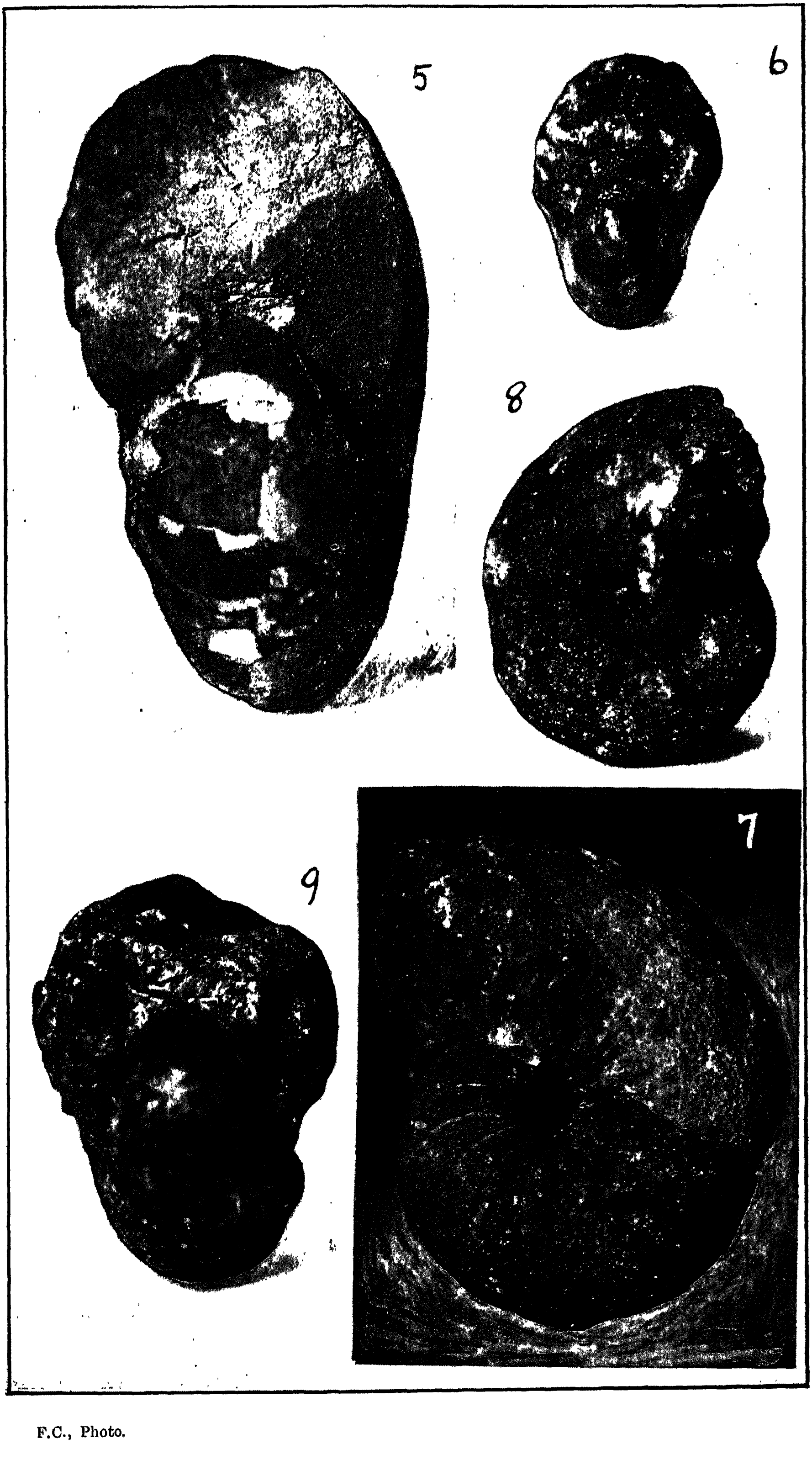

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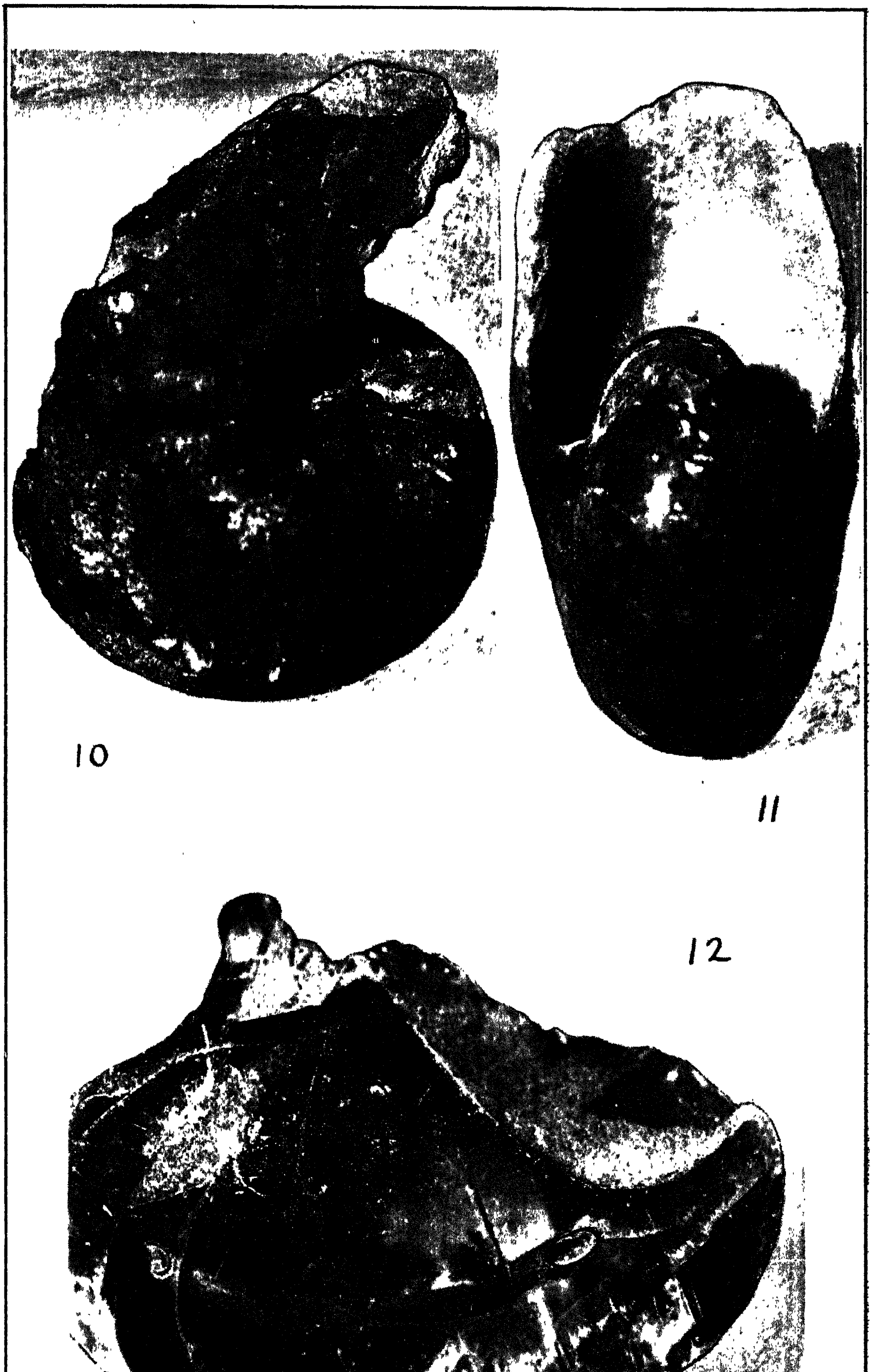

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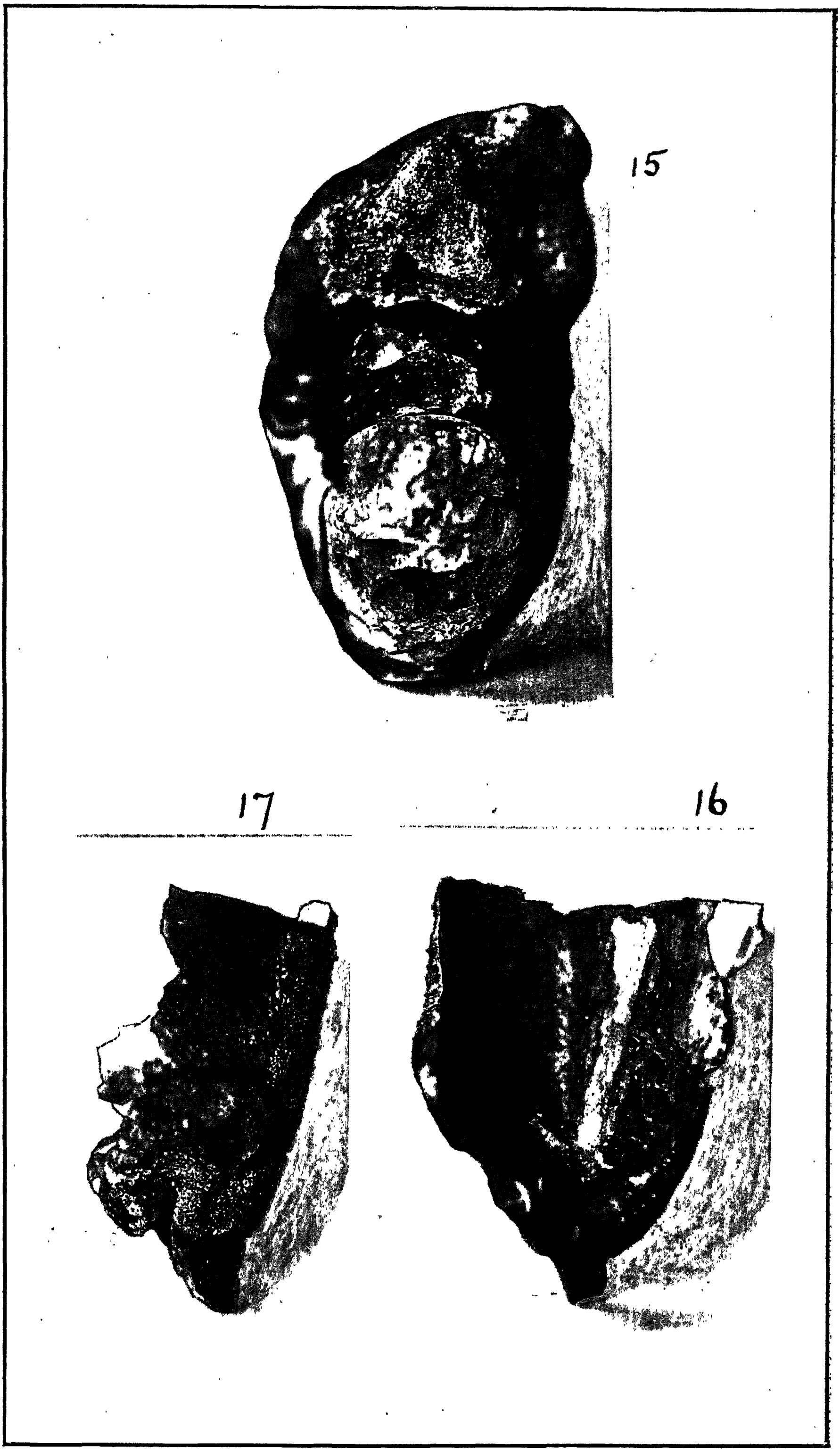

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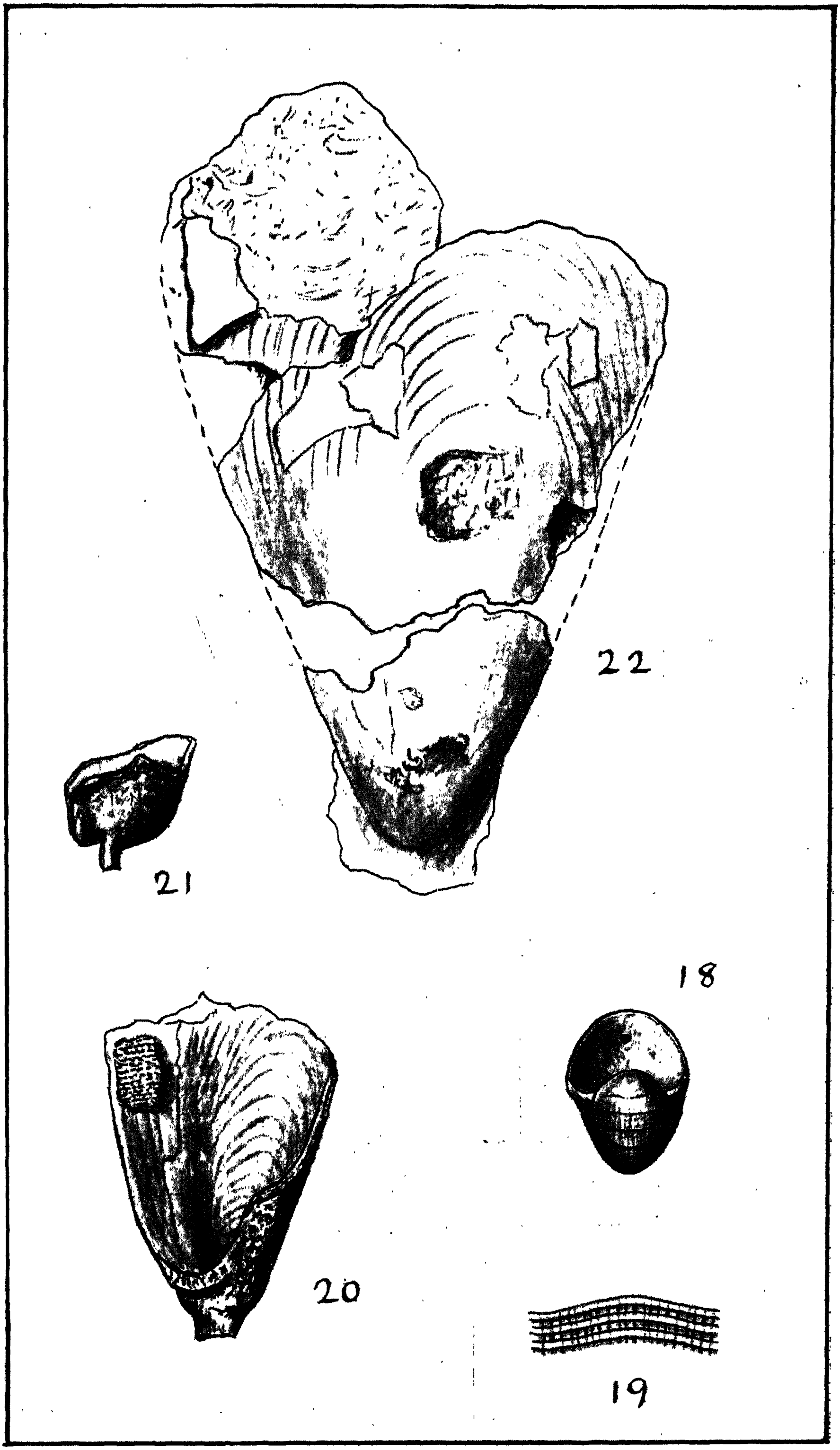

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PLATE VIII.

Fig. 18.—*Nautilus balcombensis*, sp. nov. Specimen in the brephic stage, with siphuncular orifice clearly seen on the face of the chamber, and with the superficial shell-ornament well-preserved. Balcombian. Balcombe Bay, Port Phillip. (Coll. F. A. Cudmore). Paratype. Nat. size.

Fig. 19.—*N. balcombensis*, sp. nov. Ornament in above specimen enlarged. × 3.

Fig. 20.—*Notosepia cliftonensis*, sp. et gen. nov. Balcombian. Balcombe Bay. (Coll. W. Kershaw). Paratype. Nat. size.

Fig. 21.—*N. cliftonensis*, sp. nov. Sepion in early stage of growth, showing recurved mucro. Balcombian. Balcombe Bay. (Coll. W. Kershaw). Paratype. × 2.

Fig. 22.—*N. cliftonensis*, sp. nov. The proöstracum, showing outer shell and inner concentric lamininae. Balcombian. Clifton Bank, Muddy Creek. (Coll. H. Lodge). Paratype. Nat. size.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PT. II., 1914].

ART. XXV.—*Descriptions of three unusual forms of Australites from Western Victoria.*

BY PROFESSOR ERNEST W. SKEATS, D.Sc., A.R.C.S., F.G.S.

(With Plate IX.).

[Read 10th December, 1914].

Introduction.

During a visit to the Grampians in February, 1913, in company with Mr. W. H. Ferguson, of the Geological Survey, I paid a visit to the Stony Creek basin, near Hall's gap, from which a considerable quantity of alluvial gold has been obtained. From the gold-bearing gravels and sands a large number of australites has been found from time to time. The gravels are quite shallow, and I understand that some of the australites have been obtained from a depth of a few feet below the surface. I was not successful in my search, but Mr. Charles D'Alton, of Hall's Gap, showed me some which he had found, and generously presented to me for the Geological Museum of the University, two small forms, of remarkable character.

Last week Professor Baldwin Spencer, C.M.G., F.R.S., Director of the National Museum, showed me another remarkable form of australite, from Western Victoria, recently presented to the National Museum by Mr. H. Quiney.

Professor Spencer kindly allowed me to describe this specimen, with the two presented to me by Mr. D'Alton.

Descriptions of Specimens.—See Plate.

Australite, presented by Mr. H. Quiney, to National Museum.

Measurements.—The weight determined by the chemical balance is .5330 grams.

The specific gravity determined by Joly's spring balance is 2.47

Length of australite is 20 mm. or $\frac{25}{32}$ inch.

Breadth of australite is 10.7 mm. or $\frac{13}{32}$ inch.

Maximum thickness is 3.5 mm. or $\frac{9}{64}$ inch.

Length of australite, excluding the flange, is 13 mm. or $\frac{17}{32}$ inch.

Breadth of australite, excluding the flange, is 8 mm. or $\frac{5}{16}$ inch.

Appearance of Australite.

General characters.—The specimen is shaped somewhat like a pine-seed, being elliptical in outline, flat above, convex below, and tapering at its edge to a thin flange, which is flat at the extremities of the specimen, and curved back on the middle part of the upper surface. The flange has been slightly chipped near each extremity. The colour of the australite ranges from light yellow in the thin flange, through bottle-green to black, but even the thickest part is translucent.

Flat or upper surface.

Examined under the microscope with a 2-inch objective, numerous small pits of hemispherical shape are noticed on the middle part of the upper surface. Near the flange these pass into semi-cylindrical grooves, which are recurved at the junction with the flange. The recurving is in opposite directions on opposite sides of the central part of the flange. Near the extremities of the longer axis of the specimen the grooves run out into the flange parallel to the longer axis of the specimen. This recurving of the grooves alluded to above is what would be expected to occur if they were formed while the glass was still plastic and rotating about an axis at right angles to the flat or upper side, while the turning upwards of the central part of the flange might be expected to occur in a plastic body as a result of resistance from the air, while the body was moving in the direction of the assumed axis of rotation.

Convex or lower surface.

Pits and grooves are also noticed on this surface of the specimen. In the middle of the specimen they are hemispherical, at the margins of the central part they become semi-elliptical to semi-cylindrical, and in the flange, especially at the extremities of the longer axis, they are drawn out to linear grooves.

Examination of interior of Australite.

For this purpose the australite was immersed in water in a watch glass, and examined under the microscope.

The specimen shows no sign of crystals or incipient crystals; it is completely glassy. In polarised light the central parts are completely isotropic, but the marginal parts, especially the thin part of the flange, exhibit grey to white polarization colours, indicating the existence of a state of strain in the glass of the margin and flange of the australite.

Boat-shaped Australite presented by Mr. Charles D'Alton to Geological Museum of the University.

Measurements.—The weight determined by the chemical balance is .4632 grams.

The specific gravity determined by Joly's spring balance is 2.43.

Length of australite is 20 mm. or $\frac{25}{32}$ inch.

Breadth of australite is 9.5 mm. or $\frac{3}{8}$ inch.

Maximum thickness is 3 mm. or $\frac{1}{16}$ inch.

Breadth of australite, excluding the flange, is 4 mm. or $\frac{5}{32}$ inch.

Appearance of Australite.

General characters.—The specimen is more or less boat-shaped. It is elliptical in outline, with an upper surface, whose central part is approximately cylindrical, and with a flange curved upwards, imparting a general concave appearance to the upper surface. Much of the flange has been lost by fracture, but in one place appears to be unbroken, and there the outer rim of the flange is slightly curved back, and appears to be fluted. The specimen is bottle-green to black in colour.

Concave or upper surface.

The central convex or cylindrical portion has a slight constriction or "waist" developed half-way between the extremities. The latter taper off towards a point. The surface of the central portion shows small hemispherical pits, but most prominently developed, especially near the junction with the flange are long, semi-cylindrical grooves, running generally parallel to the longer axis of the australite, and curving in at the "waist," and outwards beyond it. A few short grooves run nearly at right angles to these across the central convex portion. The flange does not show a constriction to a "waist," and exhibits on its surface small hemispherical pits.

Convex or lower surface.

This shows a few longitudinal grooves near the flange, but the general surface is covered with a large number of pits, some small and hemispherical, others large and flatter, as if adjacent pits had become confluent.

Examination of interior of Australite.

The australite was immersed in water in a watch glass, and examined under the microscope.

The specimen is completely glassy, showing neither crystallites or microlites, and is completely isotropic, except for slight strain polarization effects at the thin ends of the australite.

Disc-shaped Australite presented by Mr. Charles D'Alton to Geological Museum of the University.

Measurements.—The weight determined by the chemical balance is .3184 grams.

The specific gravity determined by Joly's spring balance is 2.41.

Length of australite is 13 mm. or $\frac{1}{2}$ inch.

Breadth of australite is 11.8 mm. or $\frac{15}{32}$ inch.

Maximum thickness is 1.2 mm. or $\frac{3}{64}$ inch.

Length of australite, excluding the flange, is 5.2 mm. or $\frac{13}{64}$ inch.

Breadth of australite, excluding the flange, is 45 . mm. or $\frac{3}{16}$ inch.

Appearance of Australite.

The specimen is approximately disc-shaped, and almost circular in outline. It is dark bottle-green in colour, and quite translucent, owing to its thinness. The flange is much broader, and slighter thicker than the central portion. The edge of the flange is perfect, except for a small chip. It is smooth, except for small pits and quite clearly could never have formed a portion detached from a glass bubble.

Upper Surface.—The whole surface is crowded with minute pits, some hemispherical in shape, some shallower, and many are confluent at their edges. In addition shallow grooves are seen forming a closed, roughly elliptical curve tangent at one point to the central portion, and passing out to near the margin of one part of the flange. The junction of the flange with the central portion is depressed, and the flange as a whole is thicker than the central portion.

Lower Surface.—The lower surface is almost flat. It is covered with minute pits, and in the central portion with sub-parallel grooves trending in the direction of the longer axis of the specimen. These grooves, however, fail to reach the margin of the flange.

Examination of interior of Australite.

The australite was immersed in water in a watch glass, and examined under the microscope.

On focusing beneath the surface of the australite, it was noticed that the pits or bubbles were internal, as well as external, and were in places arranged roughly in rings. A few still smaller gas bubbles, with dark borders, were also noticed. The specimen was entirely glassy and isotropic, except for slight evidence of strain polarization.

Conclusion.

The three australites above described are remarkable, and I think constitute more or less distinct types from any hitherto described. The best and most complete reproduction of different types of australites is given by Mr. E. J. Dunn,[1] and includes button shaped, ellipsoidal, dumb-bell shaped, and almost spherical forms.

To these must now be added the "pine-seed" type, the "boat-shaped" type, and the discoidal type.

The three specimens described are remarkable also for their small dimensions and light weight. I believe the disc-shaped specimen from the Stony Creek Basin in the Grampians is the smallest and lightest australite hitherto described.

DESCRIPTION OF PLATE.

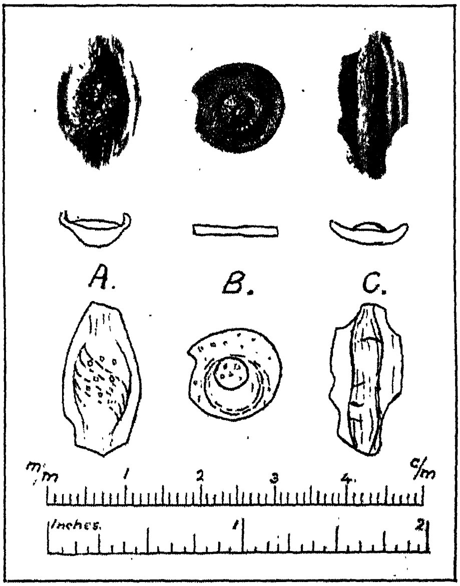
A is the pine-seed type of australite. (Nat. Museum collection).

B is the disc-shaped type of australite. (Geol. Dept. Univ. collection.

C is the boat-shaped type of australite. (Geol. Dept. Univ. collection.

Below each australite is a drawing of a transverse section through the australite, and a drawing of the upper surface, showing the flange and peculiar distribution of grooves. Millimetre and inch scales are shown.

1 Records of Geol. Survey of Victoria, vol. ii., pt. 4, 1908, pp. 202-207. Bulletin of Geol. Survey of Victoria, No. 27, 1912.


A.
B.
C.
m/m
1
2
3
4.
c/m
Inches.
1
2

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PT. II., 1914].

ART. XXVI.—*Note on Eucalyptus alpina, Lind., and its Essential Oil.*

BY R. T. BAKER, F.L.S., AND H. G. SMITH, F.C.S.,

Technological Museum, Sydney.

(Communicated by Prof. A. J. EWART, D.Sc.).

[Read December 10th, 1914].

This specimen was discovered by Sir Thomas Mitchell, in 1836, on the summit of Mt. William at an elevation of over 4,000 feet, and, so far, is endemic to Victoria. Until quite within the last year or so, this was the only locality recorded for it, none other being given by Bentham in his "Flora Australiensis," or by Mueller in his "Eucalyptographia," Dec. 11, where this species is figured.

It has, however, now been found by Mr. J. W. Audas to occur at Hall's Gap, in the Grampians, and the leaves from which this oil was obtained were collected "on that portion of the Serra-range lying between Hall's Gap and the Victorian Valley, Grampian Mountains," where it grows on black sandy loam. Mr. C. W. D'Alton, of that locality, informs us that the species seldom grows below an altitude of two thousand feet, and appears to flourish best at about 3000 feet above sea level. The height of the tree is between twelve and thirty feet, being a robust spreading tree, with rough bark at the foot of the trunk and smooth above.

Timber.—The timber is very tough, and stands heavy winds well, but becomes hollow with age.

Remarks.—Being confined to so restricted an area, one would hardly expect to find any variations, and Mueller, who figures and describes it in his "Eucalyptographia," does not give or refer to any. Additional collections of material, however, show that the fruits, at least, really do vary in shape. Those delineated by Mueller might be taken as the extreme in size and contour of rim, which is there shown to be domed, but specimens in this herbarium show the rim to be, even in mature fruits, quite truncate, and in others even half countersunk. The fruit is also occasionally ribbed.

The smaller form of capsule is not unlike that of *E. capitellata* in shape, otherwise the features appear fairly constant.

Essential Oil.—We are indebted, through Mr. Audas, to Mr. C. W. D'Alton, of Hall's Gap, Grampians, Vic., for the material for chemical investigation.

The leaves with terminal branchlets were collected from trees 12 to 30 feet high.

The leaves, which were thick and coriaceous, showed considerable oil glands, but these must have been largely empty, judging from the yield of oil, as this was only 0.36 per cent.

The crude oil, which was thin and mobile, had a terpene-like odour, suggesting that of turpentine. Phellandrene was not detected, and Eucalyptol was only present in small amount. The presence of the solid paraffin peculiar to some Eucalyptus oils (Proc. Roy. Soc., N.S.W., July, 1913) was also determined.

The results show this oil to consist largely of pinene, the laevo-rotatory form predominating slightly. Although belonging to the group of Eucalypts producing a Eucalyptol-pinene oil, yet the species has no commercial value as an oil-producing plant, the yield being much too small, while the oil itself is deficient in oxygen-bearing constituents.

The crude oil had the following characters:—

Specific gravity at 15° C. = 0.8973.

Rotation a_D = —2.8°.

Refractive index at 15° C. = 1.4779.

Insoluble in 10 volumes 80 per cent. alcohol, and, owing to the presence of paraffin, not entirely soluble in 90 per cent. alcohol.

The saponification number for the esters was only 2.6, so that esters were only present in very small amount.

On re-distilling the crude oil, the usual amount of acid water and volatile aldehydes for this class of Eucalyptus oils came over below 155° C. (corrected). Between 155° and 163° no less than 66 per cent. distilled.

This fraction, which contained a little Eucalyptol, had the following characters:—

Specific gravity at 15° C. = 0.8669.

Rotation a_D = —3.9°.

Refractive index at 15° C. = 1.4678.

This fraction had an odour of turpentine, and gave the characteristic nitrosochloride for pinene, thus showing this fraction to consist largely of that terpene.

Between 163° and 215°, 16 per cent. distilled (14 per cent. below 180°). This fraction, which contained Eucalyptol, gave the following:—

Specific gravity at 15° C. = 0.8783.

Rotation $a_D = -3.2°$.

Refractive index at 15° C. = 1.4680.

Between 215° and 285° only 1 per cent. came over, leaving no less than 16 per cent. in the still, boiling above the latter temperature. This residue contained some paraffin, the remainder consisting, perhaps, largely of polyterpenes.

A portion of the crude oil was distilled to 190° C., and the Eucalyptol determined in this by the resorcinol method. The result showed 10.2 per cent. of Eucalyptol to be present in the crude oil.

[PROC. ROY. SOC. VICTORIA, 27 (N.S.), PART II., 1914].

ART. XXVII.—*Some Observations on the Methods of Using the Agglutination Test in the Diagnosis of Disease in Bovines caused by the Bacillus of Contagious Abortion.*

BY H. R. SEDDON, B.V.Sc.

(Veterinary Research Institute, University of Melbourne).

[Read 10th December, 1914].

1. Materials required on which to found a Diagnosis of Contagious Abortion.

The materials which may be examined are:—

(1) Vaginal or Uterine Exudate after Parturition.
(2) Foetus or Foetal membranes.
(3) Blood serum.
(4) Milk.

In animals which have recently aborted (1) and (2) are applicable, but in animals from which these were not secured, or in others in which it is desirable to diagnose infection in the absence of abortion, or at a time remote from the act of abortion, the most commonly used material is (3) Serum. This is of especial value because of its being easily obtained from cows at all stages of the disease from shortly after infection onwards; also from male animals, proving that they are susceptible to infection, and from laboratory animals, such as guinea-pigs. The drawback is the difficulty of obtaining the serum from a whole herd in the country where dairymen would have to collect the samples.

It was because of this difficulty that investigations have been made as to the possible use of (4) Milk. As far as I have been able to ascertain, this material, on account of its physical properties, has not been used to any extent for the agglutination test. In some respects milk itself is an unsatisfactory material, and for that reason whey, prepared by the artificial clotting of milk, has been used. Although these investigations are incomplete, they furnish evidence strongly suggesting that it will be found satisfactory for diagnosis. Should this be so, milk, from its ease of collection, would be the ideal material for examination in the case of lactating animals.

In this section will be found results of certain researches conducted on diagnosis from specimens of uterine exudate and of whey.

When *whey* has been used the agglutination test alone has been applied to it.

When using exudate,[1] *the means available in the hands of the bacteriologist are:—*

(1) Microscopical examination.

(2) Cultures.

(3) Inoculation of animals.

(4) Agglutination test; and

(5) Complement fixation test.

1. *Microscopical examination.*—To a person who is in the habit of frequently examining specimens containing the *bacillus abortus* the diagnosis presents no great difficulties, especially if the organisms are plentiful and typically arranged. On the other hand there are met with in vaginal or uterine material bacteria which simulate more or less the *B. abortus*, and here the other tests aid to confirm the diagnosis.

2. *Cultures.*—For these to be satisfactory, the material should be as free as possible from contamination by other organisms. In Australia a cow is frequently at grass when abortion takes place, and may have aborted some days before the stockman sees her. The discharge in such cases is sure to be badly contaminated.

Also, the discharge should obviously not contain any antiseptic. It sometimes happens that one is called upon to examine material from a cow which has been syringed out with lysol, the specimen smelling strongly of the antiseptic. For these reasons this method is of very limited application.

3. *Inoculation of Animals.*—The remarks made about contamination and antiseptics under the last heading apply equally here. Nevertheless, this method of diagnosis has been used here with success, guinea-pigs being used. Owing to the length of time before marked lesions develop one resorts to the agglutination test of the blood serum of the guinea-pig to determine whether infection by the specific organism has taken place.

4. *Agglutination Test.*—This has proved valuable in diagnosing a sample of exudate, in which the microscopical findings were doubtful, and where, on account of great contamination, cultures were not obtained.

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1 The word exudate is used throughout to mean vaginal discharge containing uterine exudate.

It has been found very delicate, as little as 0.0025 c.c. of exudate causing agglutination. From one of these positive cases the blood serum, secured 16 days later than the exudate and 17 days after abortion, gave an exactly similar agglutinating titre to the exudate. (See Cow II., "Bluey.")

Further, exudate may be kept until it is fairly swarming with bacteria, and yet show little loss of agglutinant action. Also exudate diluted with carbolised saline (10% of exudate in saline containing 0.5% of carbolic acid) shows little loss of agglutinating bodies.

Exudate from a healthy cow which calved at the Institute was tested, and even in an amount of 0.25 c.c., failed to give any agglutination.

5. *Complement Fixation Test.*—No opportunity has presented itself of applying this test to exudate, but, judging from the results with the agglutination test on this material, there seems to be no reason why it should not be of use for diagnostic purposes.[1]

Details of Cows.

1. *Normal Cow.*—This animal was kept at the Institute in connection with another experiment. She calved, after the usual signs of on-coming parturition, the offspring being of full size, and vigorous.

Exudate secured the day she calved gave no agglutination with 0.25 c.c.

Whey from milk taken eleven days after calving gave a positive agglutination with 0.25 c.c., but a negative with 0.05 c.c.

II. Cow, "Bluey."—Detailed history not available. Aborted on 1st September, 1913. *Exudate*—in appearance typical of the disease—was secured from the vagina next day. It was tested four days later, and agglutinated at 0.15 c.c., this being the smallest quantity used. Twelve days later the end-point was determined to be 0.0025 c.c., the material used in this test having been left in the bottle and being now fairly putrid. At the same time material which had been diluted with carbolised saline twelve days ago now gave a reaction with 0.005 c.c.

Microscopical examination of exudate showed long chains of bacilli, streptococci, and also some clumps of bacilli the size of *B.*

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1 An opportunity has since presented itself of testing, by the Complement Fixation method, a sample of vaginal exudate from a cow which had recently aborted. The result was positive, thus showing that the test may be also availed of for diagnosis as is suggested above.

typhosus. Smears from placental membrane showed streptobacilli and streptococci, as above. Neither specimen showed bacilli which could be definitely recognised as the bacilli of contagious abortion. *Cultures* of the *B. abortus* were not obtained, the tubes being overgrown by the other organisms present.

III. Cow, "Baptist."—Aborted on 22nd June, 1914. *Exudate*, secured from the vagina two days later, gave agglutination with 0.0025 c.c. *Microscopical examination of exudate* showed numerous organisms morphologically like *B. abortus*.

Inoculation of Animals.—Guinea-pig 488 was inoculated subcutaneously with exudate, and its serum, tested nine days later, gave no agglutination; 40 days after inoculation a positive agglutination was obtained with 0.15 c.c. of serum; 76 days after inoculation 0.0025 c.c. of serum gave a positive agglutination; 95 days after inoculation the animal was killed.

Post-mortem Examination.—Animal in good condition and all organs apparently normal, except the spleen, which showed a nodular appearance externally and on section numerous very small greyish foci, which looked rather more like enlarged and prominent malpighian bodies than foci of necrotic material. On smears, no organisms could be detected.

Guinea-pig 489, inoculated intraperitoneally with exudate, was tested 40 days after inoculation, when the serum gave a positive agglutination reaction.

IV. Cow, "Garfish."—Calved 5th July, 1914, not being due till the 17th of the same month, but the owner remarks: "Calf full size, but dead." *Exudate* was secured two days after parturition, and gave no agglutination when tested, using 0.05 c.c.

Microscopical examination of exudate failed to demonstrate the presence of B. abortus, and cultures gave negative results.

Animals Inoculated.—Guinea-pig 491, inoculated intraperitoneally with exudate, was tested three times (the last test 113 days after inoculation), the serum giving no agglutination. Guinea-pig 492, inoculated subcutaneously with exudate, tested one month after inoculation, gave a similar negative result.

Whey from milk collected eight days after calving, gave a negative result with 0.05 c.c.

2. Technique Employed.

In the following pages details of the technique employed in the use of all the materials examined are given with a view to a

standardisation of the test in the hands of different workers, so that the interpretation and comparison of results may be possible and accurate.

a.—The use of whey and the value of the method.

That the specific agglutinins of *Bacillus abortus* may occur in milk has been mentioned by MacFadyean and Stockman, (1) in the Appendix to Part 1 of the Departmental Committee's Report, p. 28, where they say: "We also found that the milk of an animal which had aborted possessed agglutinating properties up to 1 in 25, but, owing to the opacity caused by the addition of milk to a culture, milk is unsuitable for testing purposes." Whether this product has been used at all in diagnosis I am not aware.

It is obvious that if milk, or milk products, could be used it would be advantageous, owing to the ease of securing specimens; but, as milk, even diluted, is unsatisfactory on account of its physical properties, experiments were made with whey. The whey was obtained by clotting milk with Lactic Acid, the technique being as follows:—

To 9 c.c. of milk, 1 c.c. of a 10% aqueous solution of lactic acid is added and mixed. The coagulated milk is then filtered through either cotton-wool and filter-paper, or filter-paper alone, the latter method being usually applied.

The whey is then diluted, one part to nine parts of carbolised saline (Acid. Carbol. liq. 0.5, Sod. chlor. 0.85, water 100), to form the basal dilution 1 in 10, and incubated over-night. Incubation and subsequent filtration are found necessary, otherwise there may be a deposit of albuminous material, which, though unlike the typical deposit of agglutinated organisms, is not desirable, since it may lead to confusion in reading the results.

With the diluted, incubated, and filtered whey, four tubes, each receiving 0.5 c.c. of standard bacterial emulsion, are put up, containing the following amounts of the basal dilution of whey (1 in 10).

	A.		B.		C.		D.
	1.0	-	0.2	-	0.1	-	0.05 c.c.
(representing	0.1	-	0.02	-	0.01	-	0.005 c.c. of pure whey).

As a control, 1 c.c. of diluted whey is put in a tube without any emulsion.

Carbolised saline is then added till the amount of liquid in each tube is approximately 1.5 c.c.

Thus the series of tubes contain :—

	A.	B.	C.	D.
Whey	0.1	0.02	0.01	0.005 c.c.
Emulsion	0.5	0.5	0.5	0.5 c.c.
Saline	0.9	0.98	0.99	0.995 c.c.

The tubes are then shaken and put in the incubator till next day, when the results are read. Further incubation shows little alteration, a tube showing "partial" agglutination—*i.e.*, small deposit, with no "clearing" of the supernatant fluid at the end 18 to 24 hours, may be complete at the end of 36 to 48 hours.

Whey, from milk which had been kept 20 days at room temperature, and clotted naturally, has also been tested, when it was found that this bacterially-produced whey exhibited the same titre as the whole milk.

A large number of experiments with whey have been performed, but as yet no conclusion has been come to as regards the limiting titres upon which a diagnosis may be made. It has been found that the agglutinins in whey increase and decrease in much the same manner as they do in blood serum. The work to date has been chiefly among cows on a property where the disease has been in existence for a number of years, but where the abortions, since the investigations commenced, have been very few—not sufficient to warrant a definite opinion as to the comparative value of whey versus serum. Sufficient has been done, however, to warrant investigation of the value of whey as a material for diagnosis by other workers.

b.—Collection of Serum from Cattle and Guinea-pigs.

Occurrence of the Agglutinins in the Blood of Steers.

Cattle.—Undoubtedly the most satisfactory method of obtaining serum in large quantities is by bleeding from the jugular vein, but as this method takes some time, and often necessitates the casting of the animal, another and simpler method is required where only small quantities of blood, sufficient for diagnostic purposes, are required.

It has been found that such may be best obtained from the small artery which runs with the vein extending along the centre of the dorsum of the ear. This vein is the most prominent and is easily found. The hair is clipped off, and an incision is made across the vein and the artery at a point about mid-way betwen the tip and the base of the ear. The artery may not be cut at the first incision, as

it usually lies underneath the vein, and a second rather free incision may be necessary. From this the blood spurts or drips freely, and 5 to 10 c.c. can be collected in a test-tube. The blood is allowed to clot, the clot loosened from the sides of the tube for about two-thirds of its attachment, and the tube inverted in a conical urine test-glass. After allowing this to stand for some hours, the serum may be collected free from corpuscles.

Guinea-pigs.—The following method has been found satisfactory for obtaining small quantities of serum for diagnostic purposes:—

Centrifuge tubes are put up, containing 2 c.c. of citrated carbol saline (Sod. chlor. 0.85, Sod. cit. 1, Ac. Carb. liq. 0.5, water 100). The margin of the ear of the guinea-pig is then incised with the scissors and held dependant. There is a small artery in this region from which, if it has been cut, the blood drips freely. Six drops of blood are collected in the prepared tubes. If we assume that six drops of blood are equal to 0.3 c.c., then we should have about 0.2 c.c. of serum in each tube, or a dilution of 1 in 10.

The tubes are shaken, centrifugalised, and the supernatant fluid pipetted off and tested in various quantities. Though not quite accurate, this method is sufficiently so for determining whether the animal is harbouring the bacilli, as, for example, those animals inoculated with vaginal exudate or milk from suspected cows. Healthy, non-inoculated guinea-pigs have invariably given a negative reaction, even with 0.1 c.c. of pure serum (*i.e.*, 1 c.c. of the citrated saline mixture), whereas some of our reacting guinea-pigs have given an agglutinating titre of 0.005 c.c., and in one case of 0.0005 c.c.

Examination of the Blood of Steers.

Because of the large number of cows which give a positive agglutination reaction it is important to determine whether agglutination of the Contagious Abortion bacillus is brought about by normal ox serum, and, if at all, to what extent. With a view to obtaining information on this point, experiments have been conducted with the serum of male animals never used for breeding.

The following experiments have been made with the serum of steers. The animals were for human consumption, and the blood was taken, immediately upon slaughter at the abattoirs, into a bottle containing a small quantity of strong (20%) citrate solution. The serum was obtained by centrifugalising and tested as follows:—

Basal dilutions were made containing 1 of serum to 9 of carbolised saline; the amount of standardised emulsion used in each tube was 0.5 c.c. Results:

	0.1	0.06	0.04	0.02	0.01	0.005 c.c. pure Serum.
Steer 1	–	–	–	–	–	–
2	–	–	–	–	–	–
3	–	–	–	–	–	–
4	–	–	–	–	–	–
5	+ +			+ +	+ +	+
6	–	–	–	–	–	–
7	+	S	–	–	–	–
8	–	–	–	–	–	–
10	S	S	–	–	–	–

+ + Agglutination and clearing.
+ Agglutination.
S Slight agglutination.
— No agglutination.

From the above, it will be seen that, with the exception of Steer 5, no animal gave a positive reaction with less than 0.1 c.c. of pure serum, and only one a definite agglutination with that amount. With regard to the "S" readings, as mentioned elsewhere, we do not count these as positives, as the amount of agglutination is extremely small—only perceptible on very careful naked eye examination.

The serum of the positive steer (5) was also tested by the complement fixation method, and again gave a positive reaction.

(c) *Standardisation of the Bacterial Emulsion.*

In the description of the technique adopted by other workers there is a remarkable absence of detail as to the concentration of the bacterial emulsion.

Although Mohler and Traum (2) use a method of standardising bacterial emulsion ("agglutinating fluid"), they do so by comparing it with "the old titred agglutinating fluid," but how this "old agglutinating fluid" itself was standardised they do not say, nor do they indicate what it was like in appearance.

MacFadyean and Stockman (3) prepare "an emulsion of greater turbidity than is ultimately required," and dilute it "until when viewed in one of the small tubes employed for the tests it is faintly hazy in appearance."

In this laboratory a method, based upon comparison of the emulsion to be employed with a suspension of Barium sulphate, has

been used, the idea being suggested by the "Nephelometer" of McFarland (4).

For the test the following solutions are made:—A 1% solution of Barium chloride in distilled water, and a 1% solution of Sulphuric acid in water. Three cubic centimetres of the Barium solution is then mixed with 97 cubic centimeters of the acid solution, shaken, and allowed to stand, to come to a state of chemical equilibrium.

The *B. abortus* is sown on agar in Roux flasks and incubated for two or three days, the water of condensation being run over the surface daily so as to get a good growth over the whole surface. Twenty cubic centimetres of carbolised saline (Ac. Carb. liq. 0.5, Sod. chlor. 0.85, water 100) is then added to the flasks and the growth washed off, shaken thoroughly, and passed twice through filter-paper. Dilutions of this suspension, or "emulsion," as it is generally called, are then made with carbolised saline as follows:—1 c.c. of emulsion and 1 c.c. of carbolised solution; 1 c.c. of emulsion and 2 c.c. of carbolised saline; and so on up to 1 c.c. of emulsion and 10 c.c. of carbol saline. These suspensions are the fluids to be compared with the barium sulphate mixture.

To compare, the Barium sulphate mixture is thoroughly shaken and a small tube of about 1 cm. calibre filled with the fluid, the fluids to be tested being placed in similarly sized tubes and comparisons made over printed paper. This Barium suspension is our standard of opacity for emulsion (Standard X).

Supposing the tube which approximates the opacity of the Barium mixture is that tube which contains 1 c.c. of thick emulsion and 6 c.c. of carbolised saline, then this tube is of the proper standard, and is called "Standard X." The whole of the emulsion may then be diluted down with carbolised saline to the proper strength, or kept as thick emulsion, the standard being now known. In the case instanced, the thick emulsion may be termed "7 X," thereby denoting that it requires diluting to seven times its volume—*i.e.*, adding six times its volume of carbolised saline, to prepare a standardised emulsion "X."

In our tests, in which we make the total volume of fluid in the tube up to 1.5 c.c., we use 0.5 c.c. of this standard emulsion "X" in each tube.

3. Quantitative Factors in the Agglutination Reaction.

(*a*) *Not simply a matter of dilution, but a quantitative reaction.*

An unfortunate terminology has crept into descriptions of agglutination methods—probably a relic from the descriptions of the so-called Widal reactions with the serum of typhoid patients—in which frequent use is made of the term "dilution," to express the amounts of serum (or other diagnostic fluid) necessary to bring about agglutination.

The following experiments show that the sensitiveness of the reaction is to be measured by accurate determination of the minimal quantity of serum employed; in other words, it is not simply a matter of dilution, but a quantitative reaction.

Experiments.—To determine whether—

1. The *relation* of the quantity of pure serum to the quantity of fluid in a tube (*i.e.*, degree of dilution), or
2. The *amount* of pure serum in the tube,

is the determining factor in agglutination of a particular serum.

Serum collected from a cow thirteen days previously was used, a basal dilution of 1 of serum to 49 of carbolised saline being made (1 in 50).

The emulsion was standardised in accordance with the usual method, and found to be of a standard "10 X."

Set Ia.

Ten tubes were put up, as follows:—

	A.	B.	C.	D.	E.	F.	G.	H.	J.	K.
Serum (1 in 50) -	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.25 c.c.
Carbolised saline -	0.0	0.5	1.0	1.5	2.0	1.25	1.5	2.0	2.5	1.75 c.c.
Total volume - -	1.0	1.5	2.0	2.5	3.0	1.75	2.0	2.5	3.0	2.0 c.c.
Relationship of serum to fluid - - 1 in	50	75	100	125	150	175	200	250	300	400

Of each of these dilutions 1 c.c. was put in a tube, and the tubes similarly lettered so that the *amounts* of pure serum in these tubes were:—

A.	B.	C.	D.	E.	F.	G.	H.	J.	K.
0.02	0.012	0.01	0.008	0.006	0.0056	0 005	0.004	0.003	0.0025 c.c.

Emulsion (0.05 c.c., Standard 10 X) was then added to each tube and the tubes incubated till next day, when readings were taken.

Results :—

A, B, and C, agglutination and clearing.

D and E, agglutination.

F, slight agglutination.

G, H, J, and K, no agglutination.

Set Ib.

Another ten tubes were put up similarly to above (Set Ia), but with 0.1 c.c. of emulsion (*i.e.*, double quantity) added.

Results :—

A, agglutination and clearing.

No agglutination in other tubes.

Note :—In these two sets of tubes actual *dilution* of serum in total fluid (neglecting the small amount added with the emulsion) was the outstanding test.

Set IIa.

Serum and carbolised saline were placed in tubes as in Set I. :—

	A.	B.	C.	D.	E.	F.	G.	H.	J.	K.
Serum (1 in 50) -	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.25 c.c.
Carbolised saline -	0.0	0.5	1.0	1.5	2.0	1.25	1.5	2.0	2.5	1.75 c.c.

The bacterial emulsion was added to the whole of the fluid in each tube (not to 1 c.c. of each dilution).

Emulsion added (0.05 c.c.), and tubes incubated as in Set Ia.

Result :—

Agglutination and clearing in all tubes from A to J, inclusive.

No agglutination in K.

Set IIb.

Tubes put up similarly to last set (Set IIa), but with 0.1 c.c. of emulsion (double quantity) added.

Result :—

Agglutination and clearing in A, B, C, D, and E.

No agglutination in other tubes.

The actual *dilution* of the serum in these tubes, therefore, is the same in both tests (Sets I. and II.), but the actual *amount* of serum in each tube is not the same in correspondingly lettered tubes in each test. (See Table I.)

With each set, *control tubes* were put up, containing (1) serum and saline, and (2) emulsion and saline.

Note on Readings.

"Agglutination" is to be interpreted as a definite macroscopic aggregation of organisms into clumps deposited either at bottom of tube or at bottom and along sides of tubes.

"Clearing," where the supernatant fluid is free, to the naked eye, of suspended organisms—*i.e.*, agglutination and sedimentation.

"Slight," where there is a trace of agglutination deposit—not what one might with confidence call a definite agglutination. These "slights" are read as *negative agglutinations*, in considering the agglutination titre of a serum.

TABLE I.

Set I.

Tube.	Amount of Serum.	Dilution.	a. Emulsion 0.05 c.c.	b. Emulsion 0.1 c.c.
A	0.02 c.c.	1 in 50	++	+
B	0.012 c.c.	75	++	—
C	0.01 c.c.	100	++	—
D	0.008 c.c.	125	+	—
E	0.006 c.c.	150	+	—
F	0.0056 c.c.	175	S	—
G	0.005 c.c.	200	—	—
H	0.004 c.c.	250	—	—
J	0.003 c.c.	300	—	—
K	0.0025 c.c.	400	—	—

Set II.

Tube.	Amount of Serum.	Dilution.	a. Emulsion 0.05 c.c.	b. Emulsion 0.1 c.c.
A	0.02 c.c.	1 in 50	++	++
B	0.02 c.c.	75	++	++
C	0.02 c.c.	100	++	++
D	0.02 c.c.	125	++	++
E	0.02 c.c.	150	++	++
F	0.01 c.c.	175	++	—
G	0.01 c.c.	200	++	—
H	0.01 c.c.	250	++	—
J	0.01 c.c.	300	++	—
K	0.005 c.c	400	—	—

++ Signifies agglutination and clearing.
\+ Signifies agglutination.
S Signifies slight agglutination.
— Signifies no agglutination.

Conclusions to be drawn from above.

1.—Using the same quantity of emulsion in each tube, *tubes possessing the same dilution (but different quantities) of serum do not furnish parallel results.* (Compare Set Ia. with Set IIa., Set Ib. and Set IIb., etc.)

2.—Using the same quantity of emulsion in each tube, *tubes containing the same quantity of serum do furnish parallel results.*

3.—The agglutination titre varies with the quantity of emulsion used, for, as is evident in the table (I.)—

(a) With 0.05 c.c. of concentrated emulsion (10 X), the minimum amount of this serum which will produce agglutination is 0.006 c.c.

(b) With 0.1 c.c. of concentrated emulsion (10 X), the minimum quantity of serum required is 0.02 c.c.

Experiments were then carried out to test the effect of dilution on an agglutination system.

Tubes were put up, containing :—

	A.		B.		C.		D.
Pure Serum - -	0.02	-	0.015	-	0.01	-	0.005 c.c.
Emulsion (10 X) -	0.05	-	0.05	-	0.05	-	0.05 c.c.

Test 1.—Volume of fluid in each tube made up with carbolised saline to 1 c.c.

Test 2.—Volume of fluid in each tube made up to 2.5 c.c.

Results, both tests :—

A and B, agglutination and clearing.

C, agglutination.

D, no agglutination.

Test 3.—A tube was put up, containing 0.02 c.c. pure serum and 0.05 c.c. emulsion (10 X), and carbolised saline added *up to 20 c.c.*

Result :—Agglutination.

These tests show that the dominating factor is the *quantity* of serum in each tube, and not the degree of dilution. Of course, if equal quantities of each dilution be taken for testing, the quantity of serum in the tube will vary as the dilution (as is shown in Set Ia.). On the other hand, in the practical application of the agglutination test the important figure is what may be termed the "end-point"—*i.e.*, the smallest quantity of serum which will produce agglutination with a standard quantity of emulsion. The necessity, therefore, arises for taking for all tests an exactly similar

quantity of diluted serum, hence it is advisable to refer to the agglutinating titre of a serum as "so many cubic centimetres of serum," and not as "up to a dilution of such and such." For the statement of the dilution to be of any guide to other workers this must be supplemented by a statement referring not only to the actual amount of diluted serum used, but to the actual quantity of emulsion used also.

Adopting the suggested method—*i.e.*, the statement of the exact quantity of serum used, the amount of emulsion used is the only supplementary factor required to be known, for, as is shown by these experiments, and by the following section, the amount of emulsion markedly and in a regular manner affects the agglutination titre.

b.—Influence of Quantity of Emulsion on Agglutination.

Also a note on a peculiarity of agglutination.

As is indicated in the experiments in sub-section (a) of section 3 of this paper, the quantity of emulsion present in a tube in which there is a certain definite amount of serum (or, in other words, the proportion between the amount of emulsion and the amount of serum), has a bearing on whether that particular quantity of serum will show agglutination of the bacilli or not.
whereas with 0.05 c.c. of emulsion (Standard 10 X) agglutination

The tests, Ia. and Ib. (see Conclusion 3, page 382), showed that occurred with quantities of serum varying from 0.006 c.c. up, with 0.1 c.c. of the same emulsion the smallest quantity of serum to give agglutination was 0.02 c.c.

To further elucidate this relationship, a large number of tubes, with varying proportions of emulsion and serum, were put up as indicated in the table (Table 2), in which the results are also shown. On account of the wide range in quantities over which the experiment was made, various concentrations of serum and of emulsion were used in actually making the test.

These basal dilutions were :—

Of Serum :—1 in 5, 1 in 50, and 1 in 500.

Of Emulsion :—A standard suspension "X," and also one standardised to 10 X—*i.e.*, 10 times as strong.

The quantities of emulsion used are stated throughout the table in terms of standard X emulsion, but for those tubes shown in the table as containing 1 c.c. and over of standard X emulsion, the 10 X emulsion was used; the amounts of this (standard 10 X) that

TABLE II.

SERUM. c.c. of pure Serum.	EMULSION. c.c. of Standard X. 10	8	6	4	2	1	0.8	0.6	0.4	0.2	0.1
0.2	++	++	++	++	+	+	$+_n$	++	++	++	++
0.16	++	++	++	++	++	+	+	++	++	++	++
0.12	+	+	++	++	++	+	+	+	++	++	++
0.08	—	+	+	++	++	++	$+_n$	+	+	++	++
0.04	—	—	+	+	++	++	++	$+_n$	+	+	++
0.02	—	—	—	—	+	++	++	++	++	++	++
0.016	—	—	—	—	—	+	++	++	++	++	++
0.012	—	—	—	—	—	+	+	++	++	++	++
0.008	—	—	—	—	—	—	+	+	++	++	++
0.004	—	—	—	—	—	—	—	—	+	++	++
0.002	—	—	—	—	—	—	—	—	—	+	++
0.0016	—	—	—	—	—	—	—	—	—	—	—
0.0012	—	—	—	—	—	—	—	—	—	—	—
0.0008	—	—	—	—	—	—	—	—	—	—	—
0.0004	—	—	—	—	—	—	—	—	—	—	—
0.0002	—	—	—	—	—	—	—	—	—	—	—

++ Agglutination and clearing.
$+_n$ Agglutination – supernatant fluid nearly cleared.
\+ Agglutination – supernatant fluid not cleared.
— No agglutination.

were put in being 0.1, 0.2, 0.4, 0.6, 0.8, and 1 c.c. respectively. Similarly in regard to the serum—for those tubes shown as containing 0.04 c.c. of serum and over, the basal dilution of 1 in 5 was used, the quantities of this that were put in being 0.2, 0.4, 0.6, 0.8, and 1 c.c. respectively; for those tubes shown as containing from 0.002 to 0.02 c.c. of serum a basal dilution of 1 in 50 was used, the quantities being 0.1, 0.2, 0.6, 0.8, and 1 c.c. respectively; for those tubes shown as containing less than 0.002 c.c. of serum, a basal dilution of 1 in 500 was used, the quantities of this that were put in being 0.8, 0.6, 0.4, 0.2, and 0.1 c.c. respectively.

In each tube the total quantity of fluid was made up to (approximately) 2 c.c. Control tubes were put up, (1) of serum, and (2) of emulsion, and in each case remained unchanged.

These tests show that the quantities of emulsion and of serum combining to produce agglutination bear a direct relationship to one another. The result is particularly striking if one takes the extreme results ("the agglutination and clearing," end-point, shown by + +), which are found to form a straight line when plotted as a graph.

It will also be noted that this arrangement is kept up over the whole length of the series.

One further point is evident from this table (Table 2)—namely, that there is a partial inhibition with certain proportions of emulsion and serum, as may be seen from looking at the tubes containing:—

2 c.c. emulsion and 0.2 c.c. serum;

1 c.c. emulsion, and 0.2, 0.16, and 0.12 c.c. serum;

0.8 c.c. emulsion, and 0.2, 0.16, 0.12, and 0.08 c.c. serum;

0.6 c.c. emulsion, and 0.12, 0.08, and 0.04 c.c. serum;

0.4 c.c. emulsion, and 0.08 and 0.04 c.c. serum;

And 0.2 c.c. emulsion, and 0.04 c.c. serum.[1]

Comparing these with tubes lower down in the same column where the amount of serum is less, we find that where the smaller quantities of serum are used there is again complete agglutination and clearing. Further, where larger quantities of serum are used, there is also agglutination and clearing, the inhibition thus being apparently zonary. This is well seen in the columns of tubes containing—0.8, 0.6, 0.4, and 0.2 of emulsion.

Further, in the table, this zone of inhibition is found to lie approximately parallel to the agglutination end-point; it seems,

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1 An enclosing line is used in the table to make these tubes more evident.

therefore, as if there were at least two maxima of agglutination, for a given quantity of serum, varying with the quantity of emulsion, and, between these two maxima, the zone of inhibition.

A peculiar agglutination phenomenon similar to this had been noted before with serum from the same animal.

In this previous test the same amount of emulsion was used in each tube, and the following quantities of serum was placed in tubes:—

Tube.	A.	B.	C.	D.	E.	F.	G.
	0.15	0.1	0.075	0.05	0.02	0.01	0.005 c.c.
Result	+	+	+	++	++	+	−

After incubation for 24 hours, there was agglutination deposit in all the tubes except G, but there was a marked increase of opacity of the supernatant fluid going from C. to A—*i.e.*, with the greater amount of serum. The only tubes where the supernatant fluid cleared were D and E. After incubating for a total of four days, all the tubes—A, B and C—showed clearing. Emulsion controls, it should be noted, remained unchanged—*i.e.*, were not sedimented. It was considered at the time that, as the most outstanding feature was the failure of A, B and C to sediment, the cause might be physical, and that the reason sedimentation did not occur was because of the increased viscosity in these tubes, due to the large amount of serum. In view of the further experiment detailed above in Table 2, and of the mention by Hewlett of a similar phenomenon of a zone of inhibition with *M. Melitensis*, no suggestion as to the cause is offered. No opportunity of consulting the work referred to by Hewlett has been possible, but the phenomenon, in the main, seems parallel.

The phenomenon is of importance in that an apparent falling off in the agglutinating power of a serum does not necessarily mean that the end-point is to be expected in the next tube.

There may be a zone of lessened agglutination, and then a further increase may be met before the end-point of agglutination reaction. This "end-point" of reaction figure is important in Contagious Abortion, as it affords a means of comparing an animal's condition from time to time as regards the progress of the disease.

c.—Optimum Amount of Emulsion to Use.

Having determined the points referred to earlier in this paper, the question of optimum quantity of bacterial emulsion naturally arises.

Here, again, there being no universal standard adopted, observers cannot strictly compare their results. Thus, to say that an animal, 0.05 c.c. of whose serum produces agglutination, should be considered as affected, in reality conveys no definite meaning, in view of the experiments in sub-sections (a) and (b) above, unless the amount of emulsion be stated at the same time. On the other hand, workers find by experience what is a convenient quantity of emulsion to use, based on the size of the tubes employed, etc., and having found this amount retain it as a standard and use this in future; their own results, therefore, are strictly comparable with one another, but not with those of other workers.

The following experiments were made to determine what quantity, allowing for ease of reading after 24 hours' incubation, was suitable to use.

Material.

Serum, from Cow (as used in previous tests).

Emulsion (standardised, = "10 X").

Four sets of tubes, numbered 1, 2, 3, 4, were put up, using a different quantity of serum in each set. Each set consisted of four tubes—A, B, C, and D, and the quantity of emulsion used was:—

in the A tubes	-	0.05 c.c.	(10 X emulsions)	
„ „ B „	-	0.025 c.c.	„	„
„ „ C „	-	0.01 c.c.	„	„
„ „ D „	-	0.005 c.c.	„	„

To Set I. was added 1 c.c. diluted serum (equal to 0.02 c.c. pure serum), and carbolised saline was added, to make the Total Vol. 2 c.c.

To Set II. was added 0.5 c.c. diluted serum (equal to 0.01 c.c. pure serum), and carbolised saline was added, to make the Total Vol. 2 c.c.

To Set III. was added 0.25 c.c. diluted serum (equal to 0.005 c.c. pure serum), and carbolised saline was added, to make the Total Vol. 2 c.c.

To Set IV. was added 1 c.c. diluted serum (equal to 0.02 c.c. of pure serum), and carbolised saline was added, to make the Total Vol. 20 c.c.

Controls.—Serum controls were put up, and remained unchanged.

Emulsion control tubes, of each quantity of emulsion used, with carbolised saline added, were put up, and remained unchanged.

Sets I., II., and III. were read at the end of 24 hours' incubation, the result being:—

	Emulsion.			
	A	B	C	D
	0.05	0.025	0.01	0.005 c.c.
Set I. (containing pure serum 0.02 c.c.)	+	+	+	+
Set II. (containing pure serum 0.01 c.c.)	+	+	+	+
Set III. (containing pure serum 0.005 c.c.)	–	+	+	+
Set IV. (containing pure serum 0.02 c.c.)	+	+	+	?

Note:—Set IV., at the end of 24 hours' incubation, showed positive agglutination with 0.05 c.c. of emulsion—*i.e.*, in Tube A, but not in the other tubes—B, C, and D.

In tubes B and C, containing 0.025 and 0.01 c.c. emulsion, a positive agglutination was manifest at the end of three days' incubation, but the deposit in tube D, with 0.005 c.c. emulsion, even at the end of this time, was very small indeed—in fact, barely appreciable.

The controls, it should be mentioned, remained unchanged.

From these experiments it appears as if the large volume of fluid (20 c.c.) in Set IV. affected the rate of sedimentation of the clumps of bacilli in those tubes with the smaller quantities of emulsion. As, however, such a large quantity of fluid is not used in the tubes in making a diagnostic test, these results in Set. IV. are not of great importance. In the practical application of the test the total volume of fluid in each tube is usually made up to about 1.5 c.c. A number of tests have also been made in which the total amount was 2 c.c. The tubes in Sets 1, 2 and 3, where the total volume has been made up to 2 c.c., are, therefore, of primary importance. Here it is found that such a quantity of emulsion and of total fluid have been employed that the complete agglutination reaction takes place within the first 24 hours.

Tubes of 2.5 c.c. capacity have been found very suitable in making the test, and the amounts of diagnostic material (serum, whey, etc.), and of emulsion, are, even over a large range of quantities, but involving only a few different basal dilutions, easily contained in 1.5 or 2 c.c. of fluid. Also, 24 hours is a convenient time for incubation before reading the results.

Where the total volume of fluid in each tube is made up to 1.5 or 2 c.c., with incubation extending over 18 to 24 hours, *the optimum of emulsion will be the smallest quantity which gives results that are easily read,* whether the agglutination reaction be positive or negative.

The deposit following agglutination should be such that it can be easily distinguished by the naked eye, even though, as is frequently the case, the whole of the organisms be not sedimented.

In the absence of deposit—*i.e.*, in a negative agglutination reaction, there should be such a quantity of emulsion that a tube containing it can be easily distinguished from a tube not containing any emulsion.

It is of interest here to note the naked eye appearance of the emulsion controls to the sets of tubes under review.

In four of these controls the total volume of fluid was made up to 2 c.c., with carbolised saline; in the other four to 20 c.c.

	Amount of Emulsion.	Total Volume.	Naked Eye appearance.
(1)	0.05 c.c.	2 c.c.	cloudy.
(2)	0.025 c.c.	2 c.c.	faint cloudiness.
(3)	0.01 c.c.	2 c.c.	trace of cloudiness.
(4)	0.005 c.c.	2 c.c.	no cloudiness.
(5)	0.05 c.c.	20 c.c.	faintly hazy.
(6)	0.025 c.c.	20 c.c.	trace of haziness.
(7)	0.01 c.c.	20 c.c.	haziness appreciable only on comparison.
(8)	0.005 c.c.	20 c.c.	no haziness.

Of those emulsion controls containing 2 c.c. of total fluid, it will be seen that (1) and (2) above possess such a degree of cloudiness that they are readily distinguishable to the naked eye as containing emulsion.

These tubes contain 0.05 c.c. and 0.025 c.c. respectively.

In Sets I., II., and III., of agglutination results recorded above the smallest deposit (positive agglutination), which is easily read (tubes containing 2 c.c. of fluid), is that where there is 0.025 c.c. of emulsion.

In Set IV., the only tube where (although there was the same quantity of serum in each tube), agglutination was manifest in 24 hours, was that one in which there was 0.05 c.c. of emulsion in the tube.

With this large volume of fluid (20 c.c.), no smaller quantity gave a completed reaction in 24 hours.

From these experiments, therefore, it has been concluded that the optimum amount of emulsion to use is 0.05 c.c. of "Standard 10 X" emulsion (or 0.5 c.c. of "Standard X" emulsion).

This amount, 0.5 c.c. of "Standard X" emulsion has, therefore, been adopted for use in all practical diagnostic tests for the reasons that—

(1) It gives a marked naked eye deposit (and hence is easily read), in a positive reaction;

(2) Conversely, it gives a definitely cloudy appearance (and hence is easily read), in a tube where there is no agglutination.

(3) With the total volume of fluid in the tube anything from $1\frac{1}{2}$ to 20 c.c., the agglutination reaction is complete in 24 hours.

(4) It is the minimum amount of emulsion that will answer the above requirements.

In conclusion, I wish to express my best thanks to Professor H. A. Woodruff, Director of the Institute, for permission to undertake this work, and for much kindly help and advice.

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INDEX.

The names of new genera and species are printed in italics.

END OF VOLUME XXVII.

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